Highway Performance Monitoring System

Field Manual

December 2000

U.S. Department of Transportation
Federal Highway Administration

Changes Included in December 2000 HPMS Field Manual

Chapter I:

- Table I-1 was changed to reflect the full reporting of number of lanes on minor arterials and collectors.

Chapter II:

- The definition of Public Road was changed to explicitly eliminate ferryboats from the definition (p. II-2).
- The definition of Standard Sample Data was changed to eliminate the reference to grouped urbanized areas (p. II-4).

Chapter III:

- Travel Data by Vehicle Type reporting was modified. The number of vehicle types was reduced from 13 to 6; functional systems were combined (pages III-3 to III-7).
- Eliminated Temporal Distribution of Travel Activity by Vehicle Type reporting.

Chapter IV:

- Data Item 35 was revised to include the 2-year measurement cycle for IRI (p. IV-19).
- Data Item 37 was revised to clarify the HOV code descriptions (p. IV-21).
- Data Item 54 was revised to clarify lane width measurement and coding (p. IV-24).
- Data Item 56 was revised to clarify the definition of unprotected median (p. IV-25).
- Data Item 58 was revised to clarify the definition of a shoulder when parking or a bike lane abuts the through lane (p. IV-26).
- Data Item 69 added paved in "Code for all paved sample sections" (p. IV-30).
- Data Item 70 was revised to adopt terrain definitions consistent with those found in the Highway Capacity Manual (p. IV-31).
- Data Item 71 added paved in "Code for all paved sample sections" (p. IV-31).
- Data Items 72-77 were revised to advise that grade lengths are normally measured between vertical points of intersection for HPMS (p. IV-31).
- Data Items 82 and 84-86 were revised to indicate that section specific values were requested for single unit trucks, combination trucks, K-factors, and D-factors and that statewide or functional system values should be avoided (pp. IV-33, 34).
- Data item 86 revised directional factor normal ranges (p. IV-34).
- Data Items 88 and 89 were revised to clarify the coding of left and right turning lane conditions for HPMS and change the name of the data items (pp. IV-34, 36).

This page last modified on March 26, 2001

ACRONYMS AND ABBREVIATIONS

AADT: Annual Average Daily Traffic
AASHTO: American Association of State Highway Transportation Officials
AP: Analytical Process
ARS: Average Rectified Slope
ASTM: American Society for Testing and Materials
ATR: Automatic Traffic Recorder
AWT: Average Weekday Traffic
BTS: Bureau of Transportation Statistics
CAAA: Clean Air Act Amendments
CD: Collector-Distributor
CFR: Code of Federal Regulations
CO: Carbon Monoxide
Col: Collector
C.V.: Coefficient of Variation
DLG: Digital Line Graphs
DOT: Department of Transportation
DVKT: Daily Vehicle-Kilometers of Travel
DVMT: Daily Vehicle-Miles of Travel
EPA: Environmental Protection Agency
ESAL: Equivalent Single Axle Load
FA: Federal-aid
FHWA: Federal Highway Administration
FIPS: Federal Information Processing Standards
GIS: Geographic Information System
GPRA: Government Performance & Results Act
HCM: Highway Capacity Manual
HERS: Highway Economic Requirements System
HOV: High Occupancy Vehicle
HPMS: Highway Performance Monitoring System
ID: Section Identification
Int: Interstate
IRI: International Roughness Index
ITS: Intelligent Transportation System
KMPT: Kilometerpoint
Loc: Local
LRS: Linear Referencing System
LTPP: Long Term Pavement Performance
MA: Minor Arterial
MaC: Major Collector
MiC: Minor Collector
MPH: Miles per Hour
MPO: Metropolitan Planning Organization
MPT: Milepoint
NAAQS: National Ambient Air Quality Standards
NCHRP: National Cooperative Highway Research Program
NHPN: National Highway Planning Network
NHS: National Highway System
NHTSA: National Highway Traffic Safety Administration
NIST: National Institute of Standards and Technology
OFE: Other Freeways and Expressways
OPA: Other Principal Arterial
PAS: Principal Arterial System
PAS/NHS: Principal Arterial System/National Highway System
PC: Personal Computer
PMS: Pavement Management System
PSI: Present Serviceability Index
PSR: Present Serviceability Rating
ROW: Right-of-Way
RTRRM: Response Type Road Roughness Meter
R/U: Rural/Urban
SHA: State Highway Agency
SHRP: Strategic Highway Research Program
SI: International System
SN or D: Structural Number (SN) of Flexible Pavement or Thickness (D) of rigid Pavement
SPR: State Planning and Research
STAA: Surface Transportation Assistance Act
STRAHNET: Strategic Highway Corridor Network
TEA-21: Transportation Equity Act for the 21st Century
THS: Territorial Highway System
TMG: Traffic Monitoring Guide
TMS: Traffic Monitoring System
U.S.: United States
U.S.C.: United States Code
USGS: United States Geological Survey
VKT: Vehicle Kilometers of Travel
VMT: Vehicle Miles of Travel
V/SF: Volume/Service Flow Ratio
WDS: Weighted Design Speed
90-10: 90-Percent Confidence Level with 10-Percent Allowable Error

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CHAPTER I

INTRODUCTION

BACKGROUND

The Federal Highway Administration (FHWA) has the responsibility to assure that adequate highway transportation information is available to support its functions and responsibilities, including those of the Administration and the Congress. The primary purpose of the Highway Performance Monitoring System (HPMS) is to serve these data and information needs. The HPMS provides data that reflects the extent, condition, performance, use, and operating characteristics of the nation's highways.

The provision of HPMS data is a cooperative effort with state highway agencies (SHAs), local governments and metropolitan planning organizations (MPOs) working in partnership to collect, assemble, and report the necessary information. In consultation with its HPMS partners, stakeholders, and customers, FHWA has identified the data to be reported and has provided data definitions and standards. FHWA has developed and maintains PC-based data submittal software and analytical models and techniques that FHWA and a number of States use with the HPMS data to do policy sensitive system, corridor, and subarea planning and programming. Taken together, these activities support informed highway planning, policy making, and decision making at the national, state, and local levels.

CONTENTS OF THE HPMS FIELD MANUAL

Chapter I provides general information on the background, scope, and major uses of the HPMS, provides an overview of reporting requirements and introduces the sampling concept. Chapters II through VII provide more specific information on submittal requirements and the major components of an HPMS submittal:

Chapter II	Data definitions
Chapter III	Reporting summary data
Chapter IV	Data item coding instructions
Chapter V	Linear Referencing System (LRS) reporting requirements
Chapter VI	Data update cycles
Chapter VII	Sample selection and maintenance

Additional detailed information on specific data coding, sample selection, and technical procedures and requirements are included in Appendices A through N. These appendices should be consulted by those collecting and reporting HPMS data for explanation of specific requirements, techniques, or procedures to be used in developing the HPMS data set for FHWA.

USES OF HPMS DATA

Length, lane-mile, and travel data are used for apportionment of Federal-aid highway funds under the Transportation Equity Act for the 21st Century (TEA-21). HPMS data are also used for assessing and reporting highway system performance under FHWA's strategic planning process. HPMS data form the basis of the analyses that support the Condition and Performance Reports to Congress and are the source for a substantial portion of the information published in *Highway Statistics* and in other FHWA publications and media. Finally, the HPMS data are widely used throughout the transportation community, including other governmental interests, business and industry, institutions of higher learning, the media and general public. Table I-1 contains information on the source of selected length, lane-mile, and travel data from the HPMS data set.

Table I-1. Sources of selected HPMS data

HPMS Data	Rural Functional Systems					
	Interstate	**Other Principal Arterials**	**Minor Arterial**	**Major Collector**	**Minor Collector**	**Local**
Interstate Lane Miles Interstate VMT	Universe Universe					
Non-Interstate PAS Lane Miles Non-Interstate PAS VMT		Universe Universe				
FA Highway Lane Miles 1/ FA Highway VMT 1/	Universe Universe	Universe Universe	Universe Sample 2/	Universe Sample 2/		
NHS Lane Miles	Universe	Universe	Universe	Universe	Universe	Universe
Miles Lane Miles VMT	Universe Universe Universe	Universe Universe Universe	Universe Universe Sample 2/	Universe Universe Sample 2/	Universe Universe 3/ Summary 4/	Universe Universe 3/ Summary 4/
Total Public Road Miles	Certified Mileage --					

HPMS Data	Urban Functional Systems					
	Interstate	**Other Freeways & Expressways**	**Other Principal Arterial**	**Minor Arterial**	**Collector**	**Local**
Interstate Lane Miles Interstate VMT	Universe Universe					
Non-Interstate PAS Lane Miles Non-Interstate PAS VMT		Universe Universe	Universe Universe			

FA Highway Lane Miles 1/ FA Highway VMT 1/	Universe Universe	Universe Universe	Universe Universe	Universe Sample 2/	Universe Sample 2/	
NHS Lane Miles	Universe	Universe	Universe	Universe	Universe	Universe
Miles Lane Miles VMT	Universe Universe Universe	Universe Universe Universe	Universe Universe Universe	Universe Universe Sample 2/	Universe Universe Sample 2/	Universe Universe 3/ Summary 4/
Total Public Road Miles	Certified Mileage --					

1/ Universe data are used to estimate lane-miles & VMT for the few miles of NHS that are on the minor collector & local functional systems.
2/ Expanded sample data are used.
3/ Universe miles times 2 (lanes) are used. States are not required to report number of through lanes on these systems.
4/ Summary data are used. States are not required to report section level AADT on these systems.

Definitions:
Universe: Data reported for all roadway links in the system.
Sample: Data reported for a randomly selected sample of roadway links in the system.
Summary: Data reported in aggregated form by functional system.
PAS: Principal arterial system made up of interstate, other freeways & expressways, and other principal arterial systems.
VMT: Vehicle miles of travel.
FA: Federal-aid.
NHS: National highway system.

Table I-2 provides information on how HPMS data are used in the Federal-Aid Highway Program apportionment formula.

Table I-2. HPMS Data Used for Apportionment

Fund	Factors	Weight
Interstate Maintenance	Interstate System Lane Miles	33 1/3 %
	Vehicle Miles Traveled on the Interstate System	33 1/3 %
National Highway System (NHS)	Lane Miles of Principal Arterial Highways (excluding Interstate System)	25 %
	Vehicle Miles Traveled on Principal Arterial Highways (excluding Interstate System)	35 %
	Total Lane Miles of Principal Arterial Highways divided by the State’s Population	10 %
Surface Transportation Program (STP)	Lane Miles of Federal-Aid Highways	25 %
	Vehicle Miles Traveled on Federal-Aid Highways	40 %
Highway Safety Programs	State Population	75 %
	Public Road Miles	25 %

SCOPE OF THE HPMS

The HPMS is a nationwide inventory system that includes data for **all** of the Nation's public road mileage as certified by the States' Governors on an annual basis. This includes facilities both on and off State-owned highway systems. Each State is required to furnish annually all data requirements specified in the *HPMS Field Manual*. The District of Columbia and the Commonwealth of Puerto Rico are considered to be States for HPMS reporting purposes. United States Territories (Guam, the Commonwealth of the Northern Marianas, American Samoa, and the Virgin Islands) are required to annually report limited HPMS summary data only in addition to public road mileage certifications.

OVERVIEW OF HPMS REPORTING REQUIREMENTS

The HPMS is an integrated database that was developed in 1978 as a national highway transportation system database. It includes limited data on all public roads, more detailed data for a sample of the arterial and collector functional systems, and area wide summary information for urbanized, small urban and rural areas. The HPMS also requires the reporting of supplemental air quality non-attainment area sample data and LRS data for FHWA use in a geographic information system.

- The **statewide summary data** includes information on travel, system length, and vehicle classification by functional system and area type, in addition to land area and population by area type. The area types include rural, small urban, individual urbanized and the donut area of National Ambient Air Quality Standards (NAAQS) non-attainment areas.
- The term **universe data** refers to a limited set of data items reported for the entire public road system as individual or grouped length sections.
- HPMS **sample data** consists of data items added to the universe data that are reported for a small portion of the total highway system length. The sampled sections nominally are a fixed sample panel of highway sections that are monitored from year to year and, when expanded, represent the universe of the systems that are sampled. The more detailed information collected for a sample section is used to represent similar conditions on the associated functional system after expansion.
  - A **standard sample** contains the universe data plus additional data items related to the physical characteristics, condition, performance, use, and operation of the sampled sections of a highway. These sample data provide detailed information, which is used as the basis for evaluating change over time, and provides the basic input to the HPMS simulation models [Analytical Process (AP) and Highway Economic Requirements System (HERS)].
  - **Donut area samples** are unique in that their sole purpose is to enhance the precision of travel estimates in the area lying outside of the adjusted urbanized area(s) boundary but within the NAAQS non-attainment areas designated by the Environmental Protection Agency (EPA). Consequently, donut sample data item additions are limited to identification, annual average daily traffic (AADT) and an expansion factor. Donut area sample data are required only for those non-attainment areas using HPMS developed travel estimates for meeting EPA travel monitoring requirements.
- The HPMS LRS data provide a linear referencing system for the universe and sample data on selected highway functional systems. The represented functional systems include urban and rural principal arterials, rural minor arterials, and all National Highway System (NHS) routes and connectors. This permits the analyses of HPMS data in a geographic information system (GIS) environment.

The Manual contains reporting specifications for the various types of data in HPMS, a timetable for coordinating and updating the various data items and components of the HPMS, and information on maintaining the HPMS sample; information related to the use and maintenance of the HPMS submittal software is included in the software documentation. All HPMS data are to represent conditions as of December 31 of the data year. Since travel, length, and lane miles are used to apportion funds, it is important that these data represent the entire calendar year. Each State is expected to make an annual submittal of HPMS data in accordance with the procedures, formats, and codes specified in this Manual. Each State should also assure that there is agreement between the Certified Public Road Mileage and the total length (kilometers or miles) reported to FHWA via HPMS. After the initial reporting of LRS data, only updated information is required on an annual basis.

Regulations governing the FHWA State Planning and Research (SPR) funded work programs [23 Code of Federal Regulations (CFR), Part 420] outline responsibilities for furnishing FHWA adequate information for administering the Federal-aid highway program. Maintaining a valid HPMS database is an item of national significance; items of national significance must be adequately addressed in each State's annual work program. This extends beyond the simple reporting of data each year and includes taking actions to assure that all data are complete, current, and accurate. Although there may be other participants in the collection and reporting process, the ultimate responsibility for the accuracy and timely reporting of HPMS data lies with the State highway agency.

The submission of false data is a violation of the United States Code (U.S.C.), Title 18, Section 1020.

HPMS due date: June 15th of the year following the data year.

Send items that are in other than electronic format to:

- FHWA Division Office
- Office of Highway Policy Information
  Attention: HPPI-20, Room 3306
  Federal Highway Administration
  400 Seventh Street, S.W.
  Washington, D.C. 20590

Arrangements for delivery of items to be provided in electronic format should be made with the Office of Highway Policy Information and the Division Office on a State specific basis.

CHAPTER II

DEFINITIONS

This chapter contains definitions to be used in preparing HPMS data for FHWA. Specific details addressing summary, universe, standard and donut area sample data, and LRS locational data are contained in Chapters III, IV and V, respectively. Chapter VI contains data updating requirements and Chapter VII contains information on sample selection and maintenance. Collectively, these chapters provide necessary definitions, guidelines, coding instructions, reporting formats, and update specifications necessary to facilitate the reporting of current, consistent, and uniform data on a nationwide basis.

Certification of Public Road Mileage: An annual document furnished by each state to FHWA certifying the total public road length (kilometers or miles) in the state as of December 31st. This document is to be signed by the Governor of the State or by his/her designee and provided to FHWA by June 1st of the year following (23 CFR 460). See the definition of "Public Road".

Combination Truck or Vehicle: Any multi-unit vehicle described by vehicle types 8-13 in Chapter III.

Comment File: A text file that accompanies the HPMS data submittal to FHWA. It explains data issues, problems, deficiencies, unusual conditions, and any significant changes from the previous HPMS submittal. It may be provided as an electronic file attached to the HPMS submittal or as a separate paper submittal.

Confidence Level/Precision Level: The degree of accuracy resulting from the use of a statistical sample. For example, if a sample is designed at the 90-10 confidence (precision) level, the resultant sample estimate will be within ±10 percent of the true value, 90 percent of the time.

Divided Highway: A multi-lane facility with a curbed or positive barrier median or a median that is 1.2 meters (4 feet) or wider.

Donut Area: The area outside of the FHWA-approved adjusted Census boundary of one or more urbanized areas but within the boundary of an NAAQS nonattainment area is defined as the "donut area." In the example shown in Appendix G, the donut area includes six small urban areas and the remaining rural area.

Donut Area Sample Data: These data consist of a combination of existing standard sample data and supplementary sample data taken in the nonurbanized portion (donut area) of EPA designated NAAQS nonattainment areas. This is done to enhance the precision of the estimate of vehicle travel in the donut area to a 90-10 confidence level to meet EPA's travel monitoring requirements. Data are used primarily for establishing regional transportation-related emissions for transportation conformity purposes. Estimated travel based on these data is used for calibration and validation of base-year network travel models when required for nonattainment or maintenance areas. The sample panels consist of two unique sample stratifications within each donut area further stratified by volume group:

(1) combined rural minor arterial and small urban area minor arterial, and
(2) combined rural major collector and small urban area collector.

A discussion of the donut area sample design is included in Appendix G.

Donut Area Sample Sections: The combination of existing standard sample sections and randomly selected supplementary sample sections if needed for the donut area of an NAAQS nonattainment area. Used only to estimate travel in the donut area on the rural and small urban minor arterial, rural major collector, and small urban collector systems. The supplementary samples are chosen from the universe length of these systems. A discussion of the donut area sample design is included in Appendix G.

English Units: The term "English" refers to the United States legislative interpretation of the units as defined in a document prepared by the National Institute of Standards and Technology (NIST), U.S. Department of Commerce, Special Publication 330. Commonly used English units in HPMS are miles, feet, and inches.

Expressway: A divided highway facility with partial control of access and two or more lanes for the exclusive use of through traffic in each direction; includes grade separations at most major intersections.

FHWA-Approved Adjusted Census Urban Boundary: Designated boundaries of a Census urban place or urbanized area as adjusted by responsible State and local officials in cooperation with each other, subject to the approval by FHWA (23 U.S.C. 101). Urban and rural data in HPMS must be reported in accordance with FHWA-approved adjusted boundaries.

Freeway: A divided highway facility with full control of access and two or more lanes for the exclusive use of through traffic in each direction.

Functional Systems: Functional systems result from the grouping of highways by the character of service they provide. The functional systems designated by the States in accordance with 23 CFR 470 are used in the HPMS. Guidance criteria and procedures are provided in the FHWA publication *Highway Functional Classification: Concepts, Criteria, and Procedures*, March 1989. Functional system names and codes are included in Chapter IV.

Geographic Information System (GIS): A system for the management, display, and analysis of spatial information. For HPMS purposes, GIS includes the spatial data defining the highway network and the geographically referenced HPMS section and bridge data.

Highway: The term highway includes roads, streets, and parkways and all their appurtenances (23 U.S.C. 101).

Linear Referencing System (LRS): A set of procedures for determining and retaining a record of specific points along a highway. Typical methods used are kilometerpoint (milepoint), kilometerpost (milepost), reference point, and link-node.

LRS Data: Provides a linear referencing system for the universe and sample data on selected highway functional systems. LRS data are a required part of the annual HPMS data submittal due June 15th of each year. Specific instructions for reporting network control LRS data are contained in Chapter V. For LRS data reporting instructions, see Items 10, 11, and 12 in Chapter IV. Further guidance on updating LRS information is provided in Appendix H.

Metric Units: The term "metric" refers to the modernized metric system known as the International System (SI). Further information is available under NIST's Special Publication 811, titled *Guide for the Use of the International System of Units: The Modernized Metric System*, and the American Society for

Testing and Materials (ASTM) Standard E380-89a. Commonly used metric units in the HPMS are kilometers, meters, and millimeters. HPMS data must be reported in metric units; however, if State inventory systems are maintained in English units, the FHWA data submittal software will convert data inputs to the required metric format.

Metropolitan Planning Organization (MPO): The term MPO is used in HPMS as defined in 23 U.S.C. 134.

National Ambient Air Quality Standards (NAAQS) Nonattainment Area: An area not meeting the NAAQS is designated by EPA as a "nonattainment area" out to boundaries established under the Clean Air Act Amendments (CAAA) of 1990. HPMS data are used for travel tracking for air quality assurance purposes in nonattainment areas as required by EPA under the 1990 CAAA (Section 187) and the Transportation Conformity Rule, 40 CFR parts 51 and 93. More specifically, these data are used primarily for establishing regional transportation-related emissions for transportation conformity purposes. Estimated travel based on these data is used for calibration and validation of base-year network travel models when required for nonattainment or maintenance areas. See Appendix G for additional information.

National Highway System (NHS): The National Highway System is a network of nationally significant highways approved by Congress in the National Highway System Designation Act of 1995. It includes the Interstate System and nearly 114,000 miles of arterial and other roads and connectors to major intermodal terminals. All NHS routes and connectors must be identified in the HPMS.

Public Road: A public road is any road or street owned and maintained by a public authority and open to public travel. [23 U.S.C. 101(a)]. Under this definition, a ferryboat is not a public road.

- The term "maintenance" means the preservation of the entire highway, including surfaces, shoulders, roadsides, structures, and such traffic-control devices as are necessary for safe and efficient utilization of the highway. [23 U.S.C. 101(a)]
- To be open to public travel, a road section must be available, except during scheduled periods, extreme weather or emergency conditions, passable by four-wheel standard passenger cars, and open to the general public for use without restrictive gates, prohibitive signs, or regulation other than restrictions based on size, weight or class of registration. Toll plazas of public toll roads are not considered restrictive gates. [23 CFR 460.2(c)]
- A public authority is defined as a Federal, State, county, town or township, Indian tribe, municipal or other local government or instrumentality with authority to finance, build, operate, or maintain toll or toll-free facilities. [23 U.S.C. 101(a)]

Roadway: The portion of a highway intended for vehicular use.

Rural Areas: All areas of a State outside of the FHWA-approved adjusted Census boundaries of small urban and urbanized areas.

Single-Unit Truck or Vehicle: Any single-unit vehicle described by vehicle types 3-7 in Chapter III.

Small Urban Areas: Small urban areas are defined by Census as places of 5,000 to 49,999 urban population (except in the case of cities in Maine and New Hampshire) outside of urbanized areas. As a minimum, a small urban area includes any place containing an urban population of at least 5,000 as designated by Census. Designated boundaries of an urban place can be adjusted by responsible State officials subject to approval by FHWA (23 U.S.C. 101). Urban and rural data in HPMS must be reported in accordance with FHWA-approved adjusted boundaries.

Standard Sample Data: These data consist of additional inventory, condition, use, pavement, operational, and improvement data that complement the universe data for those sections of roadway that have been selected as standard samples. When expanded through use of an appropriate expansion factor, the data represents the entire universe from which the sample was drawn, permitting evaluation of highway system performance. The sample sections form nominally "fixed" panels of road segments that are monitored on an established cyclical basis. Samples can be added or deleted from the sample panels as the need arises.

Panels of roadway sections are established using a statistically designed sampling plan based on the random selection of road segments at predetermined precision levels. The sample is stratified by area, by functional system, and by traffic volume group. Sample selection is done randomly within each stratum (a predetermined AADT volume group) for each arterial and major collector functional highway system in rural, and for each arterial and collector functional system in small urban and urbanized areas of the State. A discussion of the HPMS sample selection design is included in Chapter VII.

Unique sampling is required for each urbanized area having $\geq$200,000 population and smaller urbanized areas that are NAAQS nonattainment areas. Rural and small urban areas (5,000 to 49,999 population) are sampled collectively statewide.

Standard Sample Sections: Sections selected at random from the universe of arterial and collector systems (excluding rural minor collector) for which additional physical and operational data elements are reported along with the universe data. A discussion of the HPMS sample selection design for the arterial and collector systems is included in Chapter VII.

State (Codes): The term "State" refers to any one of the 50 States, the District of Columbia, or the Commonwealth of Puerto Rico. The Federal Information Processing Standard Codes for States (FIPS PUB 5-2) are included in Appendix A.

Strategic Highway Corridor Network (STRAHNET): The STRAHNET includes highways which are important to the United States strategic defense policy and which provide defense access, continuity, and emergency capabilities for the movement of personnel, materials, and equipment in both peacetime and war time.

Summary Data: These data consist of annual summary reports for certain data not included in the HPMS universe and sample data set for the minor collector and local functional systems. Summary data must be coded manually onto the several summary screens contained in the HPMS submittal software. These additional data are derived from State and local sources such as statewide highway databases, management systems, Intelligent Transportation Systems (ITS) and traffic monitoring systems, and data made available from local governments and MPOs. Summary data and data screens are discussed in more detail in Chapter III.

Supplemental Sample Sections (in donut areas): Additional samples needed to obtain a donut area travel estimate at the 90-10-confidence level. A discussion of the donut area sample design is contained in Appendix G.

System Length: The total length of public roads as of December 31st of a data year that is to be reported via HPMS (see definition of public road). System length includes all public roads owned by Federal, State, and local governments, or instrumentality thereof, within the boundaries of the reporting State.

Planned, unbuilt facilities on the NHS are also reported in the HPMS system length (see Item 20 in Chapter IV).

Universe Data: Data representing total system length including National Highway System length not yet built or open to traffic. These data consist of a complete inventory of length (kilometers or miles) by functional system, jurisdiction, geographic location, (rural, small urban, urbanized, and NAAQS nonattainment areas) and other selected characteristics. Universe data fully reflect all open-to-traffic public roads in the State and contain basic information for planned, unbuilt future NHS. Universe data can be reported in **either** of the following ways:

- **Section Data**: Data reported for a continuous length of roadway that is homogeneous with respect to the physical, operational, administrative, and jurisdictional characteristics being reported. Interstate System, other freeways and expressways, other principal arterial, rural minor arterial, NHS, and all standard sample and supplementary donut area sample sections must be reported in section data form; or
- **Grouped Data**: Data reported for a group of highway sections, not necessarily contiguous, with length aggregated with respect to the homogeneous administrative, physical, and jurisdictional characteristics being reported. Grouped data can only be reported for lower order, non-NHS functional systems and non-sample road sections.

Urbanized Areas and Codes: Areas with a population of 50,000 or more, as designated by the Census. An FHWA-approved adjusted urbanized area includes the Census urbanized area plus transportation centers, shopping centers, major places of employment, satellite communities, and other major trip generators near the edge of the urbanized area, including those expected to be in place in the near future. FHWA's three-digit urbanized area codes are included in Appendix B. For multi-State urbanized areas, each State must report HPMS information for the portion of the FHWA-approved adjusted urbanized area within its State boundary.

U.S. Territories: The U.S. Territories include American Samoa, Guam, the Commonwealth of the Northern Marianas, and the Virgin Islands. The Federal Information Processing Standard Codes (FIPS PUB 5-2) are included in Appendix A. A reduced HPMS data set is required for U.S. Territories. See Chapter III.

CHAPTER III

SUMMARY DATA REQUIREMENTS

INTRODUCTION

The purpose of this chapter is to explain the HPMS summary data reporting requirements. With the exception of data on the U.S. Territories, summary data are submitted to FHWA as part of the HPMS data file. Data are coded on four summary screens included in the HPMS submittal software package. In general, only data that cannot be generated from the HPMS universe or sample data files are required to be reported via the summary screens. Summary data are primarily limited to pavement and vehicle travel information for the minor collector and local functional systems, population and land area reporting, and supplementary travel information by vehicle type. Territorial data are provided via hard copy form as shown elsewhere in this Chapter. States are not required to maintain metric data; however, data must be reported in metric units to meet FHWA's statutory metric obligations. If State inventory systems are maintained in English units, the FHWA data submittal software will convert data inputs to the required metric format.

Four summary screens are required for complete summary data reporting. Each summary screen is discussed in the following sections. For additional information, the user is directed to the documentation and help screens in the HPMS Submittal Software.

TRAVEL AND DEMOGRAPHIC DATA

This summary requires the reporting of limited vehicle travel and demographic information not available from the HPMS data set as shown in the following summary screen. The HPMS software will automatically fill the Urban Code, Name and Nonattainment Code, and Name cells shown on the screen. However, the user must code all daily travel, population, and land area value cells shown.

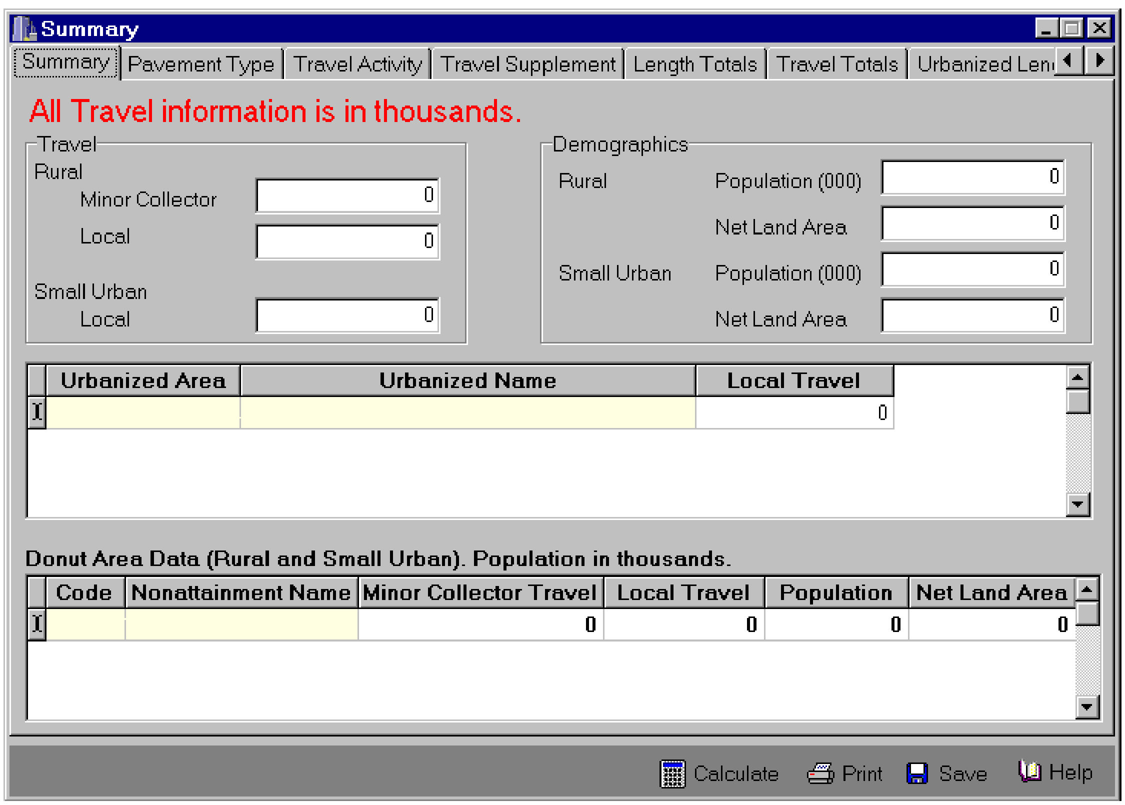


Figure III-1. HPMS Software Summary Screen

Daily vehicle travel is the amount of travel (in thousands) accumulated over a 24-hour day, midnight to midnight, for all days of a calendar year. It should reflect travel occurring on public roads, by motorized vehicles, excluding construction equipment or farm tractors. Exclude vehicle travel not occurring on public roads, such as that occurring on private access roads, parking lots, etc. Report vehicle travel that occurs on public roads for the functional systems and areas shown:

Area Type	Functional Systems	
	Local	Minor Collector
Each Urbanized Area	X	
Small Urban Statewide	X	
Rural Statewide	X	X
Each NAAQS Nonattainment Donut Area:		
Small Urban	X	
Rural	X	X

States are encouraged to improve traffic estimating practices on the local and rural minor collector functional systems. Rural areas in or near fast growing communities will require the most attention to determine changes in travel. It can be reasonably assumed that a portion of the rural minor collector and local functional systems, away from the major growth areas of the State, will experience little traffic change, thereby reducing the effort required to update this information. Travel estimates on the rural minor collector and the rural, small urban, and urbanized area local functional systems should be traffic count based. Donut area data need only be reported when HPMS is used to develop travel estimates to meet EPA requirements in NAAQS nonattainment areas. Sufficient emphasis should be placed on the development of these travel estimates to assure that they are reasonable and can be consistently generated.

Land area is determined in accordance with the U.S. Bureau of the Census definitions. Land area includes dry land and land temporarily or partially covered by water, such as marshlands, swamps and river flood plains. It also includes systems, sloughs, estuaries, and canals less than 0.2 kilometers (1/8 of a statute mile) in width, and lakes, reservoirs, and ponds less than 0.16 square kilometers (1/16 square mile) in area. [For Alaska, 0.8 kilometers (½ mile) and 2.60 square kilometers (1 square mile) are substituted for these values.] It excludes areas of oceans, bays, sounds, etc., lying within the 4.8-kilometer (3-mile) U.S. jurisdiction as well as inland water areas larger than indicated above. Land area is reported to HPMS for rural, small urban, and urbanized areas based on FHWA-approved, adjusted urban and urbanized area boundaries.

Population is based on the annual Census estimate of State resident population as of July 1st (April 1st in decennial Census years) for the calendar year for which the HPMS data are being reported. The allocation of Census-reported State resident population to rural, urban, or urbanized areas can be accomplished by using growth factors applied to the last official decennial figures, the most recent census estimate if available from the U.S. Bureau of the Census, or from population estimates available from MPOs or other State agencies. All reported population estimates must be adjusted to match the FHWA-approved, adjusted urban and urbanized area boundaries.

PAVEMENT DATA

This summary requires the reporting of limited pavement type information not available from the HPMS data set as shown in the following pavement type screen. Enter the paved and unpaved length for the specified functional systems. The Control Total is the length reported in the HPMS database for each functional system. The definitions of paved roads should be consistent with those included in Item 50, Surface/Pavement Type, codes 2 - 6.

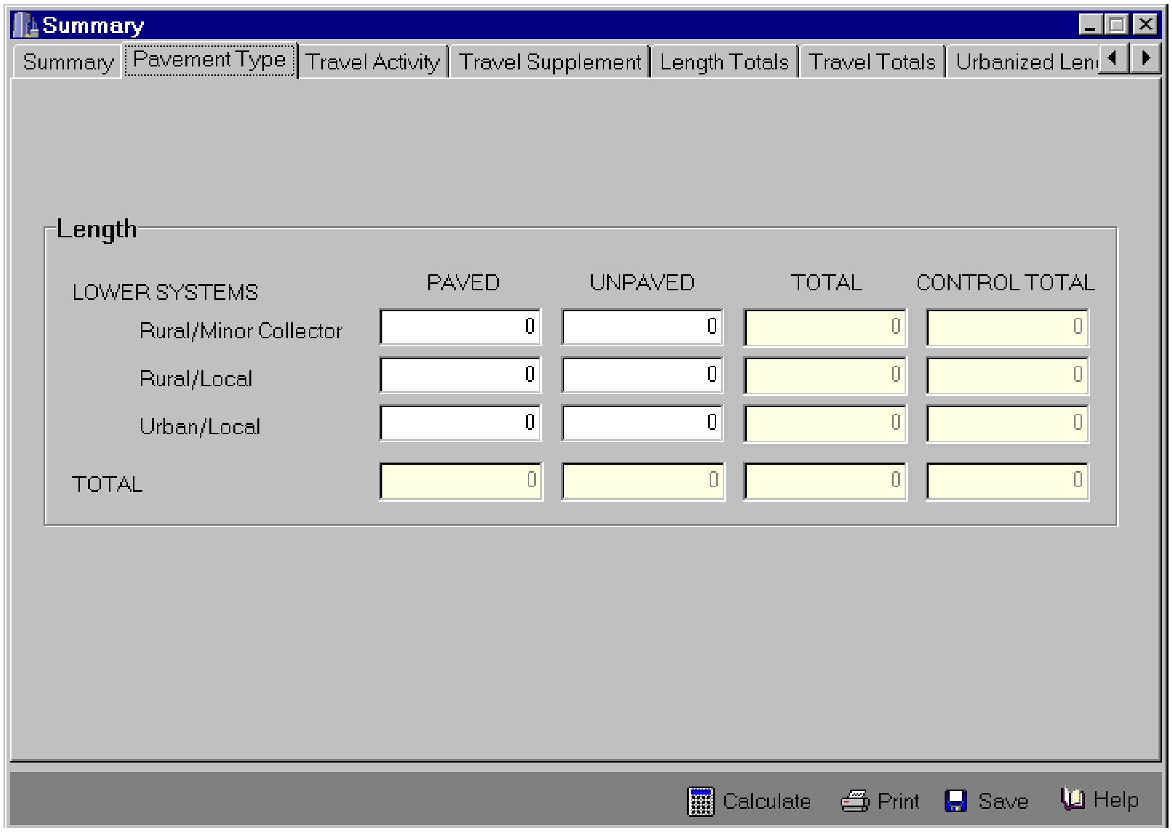


Figure III-2. HPMS Pavement Type Screen

TRAVEL DATA BY VEHICLE TYPE

This summary requires the reporting of the percentage of travel made by various vehicle types over the various functional systems of highways as shown in the travel activity screen on the following page. The percentage of travel is reported for each vehicle type relative to the total vehicle travel for each functional system or functional system groups by rural and urban areas. The values for each functional system or functional system groups must sum to 1.000 (100 percent). The individual vehicle type data cell values should be entered as a decimal number to the nearest thousandth.

States using equipment that they believe cannot differentiate automobiles from other two-axle, four-tire single-unit vehicles may report these two vehicle types as an aggregate figure. If a State that uses automated equipment normally augments its data with automobile-specific information, that data should be used to complete the summary. States are encouraged to provide automobile information distinct from other two-axle, four-tire single-unit vehicles even if estimates based on limited manual counts serve as the base. When entering aggregate data of two-axle, four-tire vehicles for a functional system, the values should be entered in the passenger car column and the "other two-axle, four-tire" column should be entered as zero.

Travel Activity by Vehicle Type

Basic Data

Shaded cells are reserved for titles and computer software generated values. Enter data in the unshaded cells only. Enter data as a decimal to the nearest thousandth.

FUNCTIONAL SYSTEM	PERCENT OF TRAVEL						
	MOTOR-CYCLES [OP-TIONAL]	PASSENGER CARS [2 AXLE, 4 TIRE]	LIGHT TRUCKS [OTHER 2 AXLE, 4 TIRE]	BUSES	SINGLE-UNIT TRUCKS	COMBINATION TRUCKS	TOTAL
RURAL							
INTERSTATE							
OTHER ARTERIAL							
OTHER RURAL							
URBAN							
INTERSTATE							
OTHER ARTERIAL							
OTHER URBAN							

Report is in English Units.

Report rural and urban vehicle activity information for interstate system and functional system groups. The Traffic Monitoring Guide (TMG) should be consulted for recommended practices regarding the development of the vehicle classification coverage count program. The procedures are flexible, allow incorporation of existing automated sites, and are sufficient to meet the area wide and standard sample section reporting needs of the HPMS. If the TMG procedures have not been fully implemented, the source and derivation of the cell values should be thoroughly documented (as discussed in Appendix F)

If the standard sample is statistically valid, estimates of percent travel for all vehicle type/functional system cells in the summary are computed as the average of all the classification sample locations within that cell. Example 1 should be used for estimates of percent travel for rural interstate and urban interstate. Example 2 should be used for estimates of percent travel for functional system groups.

Example 1: The percentage of buses on the rural interstate system is the average of the percent of buses of all vehicle classification measurements in the sample taken on the rural interstate system. If the sample consisted of 9 sections and the percent buses measured at each section were 0.9, 0.5, 1.1, 0.8, 0.4, 0.2, 1.3, 0.5, and 0.3 (total = 6.0), then the average of 0.67 would be the estimated percentage of buses and would be entered as .007 for the rural interstate cell of the summary.

Example 2: The percentage of buses on the rural other arterial group is the average of the percent of buses of all vehicle classification measurements in the sample taken on rural other principal arterials (ROPA) and rural minor arterials (RMA). If the sample consisted of 8 sections from ROPA and 7 sections from RMA, and the percent buses measured at each section were 0.8, 0.7, 0.6, 0.9, 0.7, 0.8, 0.6, 1.1 for ROPA and 1.1, 1.2, 0.5, 0.9, 0.7, 0.8, 0.6 for RMA (total = 12.0, then the average of 0.8 would be the estimate percentage of the buses and would be entered as .008 for the rural other arterial group cell of the summary.

In reporting information for the area wide Travel Activity by Vehicle Type Form, the following criteria should be followed:

- Single-Unit Trucks are described by vehicle type 5 – 7 as defined in the TMG, and exclude buses.
- Combination-Unit Trucks are described by vehicle type 8 – 13 as defined in the TMG.
- Truck-tractor units traveling without a trailer should be considered single-unit trucks.
- A truck-tractor unit pulling other such units in a "piggyback" (or "saddle-mount") configuration should be considered as one single-unit truck and be defined only by the axles on the pulling unit.
- Vehicles should be defined based on the number of axles in contact with the roadway. Therefore, "floating" axles are counted only when in the down position.
- The term "trailer" includes both semi- and full-trailers.
- Rural Other Arterial includes rural other principal and rural minor arterial functional systems.
- Other Rural includes major collector, rural minor collector, and rural local functional systems.
- Other Urban Arterial includes urban other freeways & expressways, urban other principal arterials, and urban minor arterials.
- Other Urban includes urban collector and urban local functional systems.

The States collect vehicle classification data annually at continuous permanent installations and portable sites. The site-specific classification and station description data should be sent with the truck Weigh In Motion data to the Office of Highway Policy Information (HPPI-30) using the FHWA data formats by June 15th of the year following the year for which the data are collected. Additional information about FHWA data formats is found in the TMG.

Vehicle Type Codes and Descriptions[1]

Code	Description
1	**Motorcycles (Optional)**: All two- or three-wheeled motorized vehicles. Typical vehicles in this category have saddle type seats and are steered by handlebars rather than a wheel. This category includes motorcycles, motor scooters, mopeds, motor-powered bicycles, and three-wheeled motorcycles. This vehicle type may be reported at the option of the State, but should not be reported with any other vehicle type.
2	**Passenger Cars**: All sedans, coupes, and station wagons manufactured primarily for the purpose of carrying passengers and including those passenger cars pulling recreational or other light trailers. Vehicles registered as passenger cars that are pickups, panels, vans, etc. (described as vehicle type "3") should be reported as vehicle type "3".
3	**Other Two-Axle, Four-Tire, Single-Unit Vehicles**: All two-axle, four-tire vehicles, other than passenger cars. Included in this classification are pickups, panels, vans, and other vehicles such as campers, motor homes, ambulances, hearses, and carryalls. Other two-axle, four-tire single-unit vehicles pulling recreational or other light trailers are included in this classification.
4	**Buses**: All vehicles manufactured as traditional passenger-carrying buses with two-axles, six-tires and three or more axles. This category includes only traditional buses (including school buses) functioning as passenger-carrying vehicles. All two-axle, four-tire minibuses should be classified as other two-axle, four-tire, single-unit vehicles (type "3"). Modified buses should be considered as trucks and be appropriately classified.
5	**Two-Axle, Six-Tire, Single-Unit Trucks**: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having two axles and dual rear wheels.
6	**Three-Axle, Single-Unit Trucks**: All vehicles on a single frame including trucks, camping and recreational vehicles, motor homes, etc., having three axles.
7	**Four-or-More Axle, Single-Unit Trucks**: All vehicles on a single frame with four or more axles.
8	**Four-or-Less Axle, Single-Trailer Trucks**: All vehicles with four or less axles consisting of two units, one of which is a tractor or straight truck power-unit.
9	**Five-Axle, Single-Trailer Trucks**: All five-axle vehicles consisting of two units, one of which is a tractor or straight truck power-unit.
10	**Six-or-More Axle, Single-Trailer Trucks**: All vehicles with six or more axles consisting of two units, one of which is a tractor or straight truck power-unit.
11	**Five-or-Less Axle, Multi-Trailer Trucks**: All vehicles with five or less axles consisting of

[1] Additional information about the means of identifying the vehicle types may be found in the *Traffic Monitoring Guide*, FHWA, February 1995.

Code	Description
	three or more units, one of which is a tractor or straight truck power-unit.
12	**Six-Axle, Multi-Trailer Trucks**: All six-axle vehicles consisting of three or more units, one of which is a tractor or straight truck power-unit.
13	**Seven-or-More Axle, Multi-Trailer Trucks**: All vehicles with seven or more axles consisting of three or more units, one of which is a tractor or straight truck power-unit.

[1] Additional information about the means of identifying the vehicle types may be found in the *Traffic Monitoring Guide*, FHWA, February 1995.

U.S. Territory Information

A paper summary report is required annually from the U.S. Territories of Guam, Northern Marianas Islands, American Samoa, and Virgin Islands as shown in the following form. This summary report contains the totals for population, land area, system length and vehicle travel data.

Population and land area data should be reviewed and updated annually and related to changes in decennial Census estimates. The U.S. Territories should annually submit revised estimates when changes have occurred in either population or land area for rural or small urban areas. Annual updates between decennial Censuses should be based on local trends or Census or territorial estimates.

System length should include all arterial and collector system public roads on the Territorial Highway System and other public roads that are maintained by a public authority. Under 23 U.S.C. 215, each territory must establish, with FHWA approval, a system of arterial and collector highways designated as the Federal-aid Territorial Highway System. Breakdowns by paved and unpaved surface types should be consistent with Item 50, Surface/Pavement Type. The total reported length must be consistent with the public roads mileage certified annually to the FHWA.

Daily vehicle travel should accurately indicate the usage of the public roads by motorized highway vehicles. The U.S. Territories are encouraged to use traffic count-based practices to develop travel estimates by arterial, collector, and local functional systems in rural and small urban areas. Since vehicle use in the U.S. Territories is limited to motorized vehicles maintained on the islands, other procedures, such as annual odometer surveys, could also be used to verify total travel. Procedures used to develop estimates of travel should be thoroughly documented and meet the requirements of Appendix F.

U.S. Territory Information

Territory: ______________________ Territory FIPS Code: ______

Units: [ ] English 1/ [ ] Metric 2/ Data Year: ________ Date: _______________

Category	Rural	Urban	Total
Population (1,000)			
Land Area			
Federal-Aid Territorial Highway System - Arterial:			
Paved Length			
Unpaved Length			
Subtotal			
Daily Travel (1,000)			
Federal-Aid Territorial Highway System - Collector:			
Paved Length			
Unpaved Length			
Subtotal			
Daily Travel (1,000)			
Other Public Roads:			
Paved Length			
Unpaved Length			
Subtotal			
Daily Travel (l,000)			
All Public Roads:			
Total Length			
Total Daily Travel (1,000)			

1/ English units for length and travel are miles and daily vehicle-miles (in thousands), respectively.
2/ Metric units for length and travel are kilometers and daily vehicle-kilometers (in thousands), respectively.

CHAPTER IV

UNIVERSE AND SAMPLE DATA REQUIREMENTS

UNIVERSE DATA

Certain basic inventory information is required to be reported for all open-to-traffic, public road systems in the universe portion of the HPMS data set (Items 1-46). The total length reported for all open-to-traffic records should agree with the Certified Public Road Mileage. Limited universe data for facilities on planned National Highway System (NHS) roadways that are not yet built or open to traffic also are to be reported. Universe data must be reported on a section-by-section basis for all rural arterials, urban principal arterials, the NHS and all standard sample and donut area supplemental sample sections; universe data may be reported for the remaining functional systems on a grouped length basis.

STANDARD SAMPLE DATA

Additional detailed information is required for a statistically chosen sample of roadways on major functional systems. The sampled functional systems include all but the rural minor collector, rural local, and urban local systems. The additional detailed data are reported for the standard sample portion of the HPMS data set (Items 47-98). The standard sample is intended to represent all applicable systems both on and off the State highway system. The standard sample is used for a variety of purposes including performance measurement, investment requirements modeling in support of Condition and Performance Reports to Congress, policy, other analyses, and in various publication media.

DONUT AREA SAMPLE DATA

An additional sample is required for the donut area portions of NAAQS nonattainment areas that use the HPMS as the basis of VMT estimates for air quality travel tracking and conformity purposes. The donut area supplementary sample consists of sections in the rural and small urban minor arterial, rural major collector, and small urban collector functional systems that are located outside of urbanized area(s), but within the nonattainment area boundary. The donut area supplementary sample is used to enhance the existing standard sample to achieve higher confidence levels for travel estimates. The purpose of the donut area supplementary sample is limited to the development of travel estimates. The combination of existing standard samples in the donut area plus the donut area supplementary samples makes up the donut area sample.

In addition to the universe data items, donut area supplementary sample sections need only have sample data Items 47 and 48 coded.

CODING NONUNIFORM ROADWAYS

The HPMS is an inventory system that requires reported data to represent both directions of roadway condition and operation. As a result, conflicts in data item coding may arise for specific data items under certain reporting conditions. The following provides some guidance in addressing conflicts.

Data items that involve widths, types, condition, etc., may differ in shape or dimension on each side of a roadway. To resolve this, choose one side of the facility for inventory purposes and code only the applicable data items for the chosen side of the highway. This should be done for all roadways, whether divided or undivided with common or independent alignments. The "inventory direction" should be chosen on a statewide basis (i.e., always South to North, East to West, or vice versa) and once selected never changed.

Some data items such as AADT, number of through lanes, median width, etc., reflect the complete two-way facility. Exercise extra care when reporting through lane counts and AADT because these data are used for apportionment purposes.

Appendix E requires IRI to be reported for the same direction and lane all of the time. The "inventory direction" of a facility should be used as the side where IRI is measured and reported. IRI should not be reported or averaged for both sides of a roadway.

Averages can be used for some dimensioned items that change back and forth over a section length (i.e., median width, shoulder width). In situations where a condition changes back and forth between two or more possible types over the section length, the predominant condition can be reported (i.e., shoulder type, surface type). In both cases, the lesser or worse measurement or condition for the roadway section can be reported instead.

If one part of an existing section becomes very different from the other due to a change, for instance, in the number of lanes, urban/rural break, new construction, etc., the predominant condition cannot be reported and the existing section may need to be split. A full discussion of this topic and a list of the changes that require sample splitting can be found in Chapter VII.

STRUCTURE TREATMENT

The total length of all public roads, including structures, must be represented in the HPMS; note that a ferryboat is not a public road and should not be reported in HPMS. Where structures are a part of a universe or standard sample section, the reported data items should reflect the off-structure roadway conditions. However, since the HPMS standard sample is intended to represent the off-structure roadway and its conditions, standard sample sections that exist entirely on structures should be avoided if at all possible. Structures should be used as standard samples only when a volume group sample size requirement cannot be satisfied without inclusion of a structure-only section and the section cannot be combined with a roadway section.

Existing standard sample sections totally on structures should be eliminated in favor of standard sample sections on off-structure roadways where possible. Alternately, on-structure standard samples can be combined with adjacent roadway sections and the roadway characteristics reported in HPMS. When choosing new standard samples, delete any sections that are totally on structures from the list of candidates.

When a section is entirely on a structure, only the following data items need be reported, as applicable:

Universe data items: 1-34; 37-46
Sample data items: 47-49; 54; 56; 57; 80-84; 97; 98

Code all other data items "0" or "0.0" as appropriate. Supplementary donut area sample sections that are totally on structures are permitted.

PLANNED UNBUILT FACILITY

Limited data for unbuilt facilities are included in HPMS for NHS routes only. Unbuilt facilities should only be included if there are plans for the route to be built. For unbuilt sections, only universe data items 1-19 and 30 are required.

GENERAL REPORTING REQUIREMENTS

The HPMS data are used for a variety of purposes ranging from apportionment of highway funds to public information; therefore, the use of a data item governs the HPMS required coding. Although reporting agencies may have a need for highway inventory data coded differently from the HPMS, the State's highway inventory data system must nevertheless be capable of providing the HPMS data according to the coding requirements contained in this Manual. If there is not a one-for-one relationship between the State data inventory system and the HPMS coding requirements, the State may need to obtain additional data, revise its inventory data coding to match the HPMS, or provide means to aggregate, disaggregate, or convert State inventory data into data that meets HPMS coding requirements. Where the State has a need for a data item or some physical attribute that is not needed for HPMS, the data can be retained in the State's inventory system.

DATA ITEM SUMMARY TABLE

In the following data item summary tables (Tables IV-1 and IV-2), an "A" indicates that the item is required for **all** universe, standard sample, and supplementary donut area sample sections; an "S" indicates that the item is required only if the section is a standard sample; and a "D" indicates that the item is required only if the section is a supplementary donut area sample. A blank indicates that the data item is not coded for the functional system. The following abbreviations are used in the column headings.

PAS/ NHS	Principal arterial system (PAS) includes rural and urban Interstate, urban other freeways and expressways, and rural and urban other principal arterial functional systems; National Highway System (NHS) is made up primarily of these same systems, plus a minor amount of roadways on other functional systems.
Int	Interstate
OFE	Other Freeways and Expressways
OPA	Other Principal Arterial
MA	Minor Arterial
MaC	Major Collector
MiC	Minor Collector
Col	Collector
Loc	Local

Do not rely solely on the data item summary table for data coding requirements. A number of data items require additional discussion regarding the type of section to which the data coding applies. For example, although the summary table indicates that Percent Passing Sight Distance (Item 78) is required for the rural standard sample sections, it is required only for rural paved, two-lane facilities.

Table IV-1. Universe Data Summary

Item No.	Required Universe Items								Data Item	Data Type
	Rural				Urban					
	PAS/ NHS	MA	MaC	MiC & Loc	PAS/ NHS	MA	Col	Loc		
IDENTIFICATION										
1	A	A	A	A	A	A	A	A	Year of Data	Numeric; Integer
2	A	A	A	A	A	A	A	A	State Code	Numeric; Codes
3	A	A	A	A	A	A	A	A	Reporting Units- Metric or English	Numeric; Codes
4	A	A	A	A	A	A	A	A	County Code	Numeric; Codes
5	A	A	A	A	A	A	A	A	Section Identification	Character Field
6									Is Standard Sample	Numeric; Codes
7									Is Donut Sample	Numeric; Codes
8									State Control Field	Character Field
9	A	A	A	A	A	A	A	A	Is Section Grouped?	Numeric; Codes
10	A	A			A				LRS Identification*	Character Field
11	A	A			A				LRS Beginning Point*	Numeric; Decimal
12	A	A			A				LRS Ending Point*	Numeric; Decimal
13	A	A	A	A	A	A	A	A	Rural/Urban Designation	Numeric; Codes
14	A	A	A	A	A	A	A	A	Urbanized Area Sampling Technique	Numeric; Integer
15	A	A	A	A	A	A	A	A	Urbanized Area Code	Numeric; Codes
16	A	A	A	A	A	A	A	A	NAAQS Nonattainment Area Code	Numeric; Codes
SYSTEM										
17	A	A	A	A	A	A	A	A	Functional System Code	Numeric; Codes
18	A	A	A	A	A	A	A	A	Generated Functional System Code	Software Calculated
19	A	A	A	A	A	A	A	A	National Highway System (NHS)	Numeric; Codes
20	A				A				Planned Unbuilt Facility	Numeric; Codes
21	A				A				Official Interstate Route Number	Character Field
22	A	A			A				Route Signing*	Numeric; Codes
23	A	A			A				Route Signing Qualifier*	Numeric; Codes
24	A	A			A				Signed Route Number*	Character Field
JURISDICTION										
25	A	A	A	A	A	A	A	A	Governmental Ownership	Numeric; Codes
26	A	A	A	A	A	A	A	A	Special Systems	Numeric; Codes
OPERATION										
27	A	A	A	A	A	A	A	A	Type of Facility	Numeric; Codes
28	A	A	A	A	A	A	A	A	Designated Truck Route	Numeric; Codes
29	A	A	A	A	A	A	A	A	Toll	Numeric; Codes
OTHER										
30	A	A	A	A	A	A	A	A	Section Length	Numeric; Decimal
31		A	A			A	A		Donut Area Sample AADT Volume Group Identifier[1]	Numeric; Integer
32	A	A	A		A	A	A		Standard Sample AADT Volume Group Identifier	Numeric; Integer
33	A	S&D	S&D		A	S&D	S&D		AADT*	Numeric; Integer

[1] The "A" in the summary table cells for the Donut Area Volume Group (Item 31) is meant to indicate that all data records (universe only and sample) for the noted functional systems in a donut area are to include these data.

Item No.	Required Universe Items								Data Item	Data Type
	Rural				Urban					
	PAS/ NHS	MA	MaC	MiC & Loc	PAS/ NHS	MA	Col	Loc		
34	A	A	A		A	A	A		Number of Through Lanes	Numeric; Integer
35	A	S			A				Measured Pavement Roughness (IRI)*	Numeric; Decimal
36			S			S	S		Present Serviceability Rating (PSR)	Numeric; Decimal
37	A	A	A	A	A	A	A	A	High Occupancy Vehicle (HOV) Operations	Numeric; Codes
38	A	A	A	A	A	A	A	A	Electronic Surveillance	Numeric; Codes
39	A	A	A	A	A	A	A	A	Metered Ramps	Numeric; Codes
40	A	A	A	A	A	A	A	A	Variable Message Signs	Numeric; Codes
41	A	A	A	A	A	A	A	A	Highway Advisory Radio	Numeric; Codes
42	A	A	A	A	A	A	A	A	Surveillance Cameras	Numeric; Codes
43	A	A	A	A	A	A	A	A	Incident Detection	Numeric; Codes
44	A	A	A	A	A	A	A	A	Free Cell Phone	Numeric; Codes
45	A	A	A	A	A	A	A	A	On-Call Service Patrol	Numeric; Codes
46	A	A	A	A	A	A	A	A	In-Vehicle Signing	Numeric; Codes
End of universe data items.										

Key: A = Code for "All" universe, standard sample, and supplementary donut area sample sections.
S = Code for all "Standard" sample sections.
D = Code for all "Donut" area supplementary sample sections.
* = See individual data item for exceptions.

Table IV-2 Sample Data Summary

Item No.	Required Sample Items									Data Item	Data Type
	Rural				Urban						
	Int	OPA	MA	MAC	Int	OFE	OPA	MA	Col		
IDENTIFICATION											
47	S	S	S&D	S&D	S	S	S	S&D	S&D	Sample Identifier	Character Field
COMPUTATIONAL											
48			D	D				D	D	Donut Area Sample Expansion Factor	Software Calculated
49	S	S	S	S	S	S	S	S	S	Standard Sample Expansion Factor	Software Calculated
PAVEMENT											
50	S	S	S	S	S	S	S	S	S	Surface/Pavement Type	Numeric; Codes
51	S	S	S	S	S	S	S	S	S	SN or D	Numeric; Decimal
52	S	S	S	S	S	S	S	S	S	General Climate Zone	Software Set
53	S	S	S	S	S	S	S	S	S	Year of Surface Improvement	Numeric; Integer
GEOMETRICS											
54	S	S	S	S	S	S	S	S	S	Lane Width	Numeric; Decimal
55	S	S	S	S	S	S	S	S	S	Access Control	Numeric; Codes
56	S	S	S	S	S	S	S	S	S	Median Type	Numeric; Codes
57	S	S	S	S	S	S	S	S	S	Median Width	Numeric; Decimal
58	S	S	S	S	S	S	S	S	S	Shoulder Type	Numeric; Codes
59	S	S	S	S	S	S	S	S	S	Shoulder Width -Right	Numeric; Decimal
60	S	S	S	S	S	S	S	S	S	Shoulder Width - Left	Numeric; Decimal
61					S	S	S	S	S	Peak Parking	Numeric; Codes
62	S	S	S	S	S	S	S	S	S	Widening Feasibility	Numeric; Codes
63	S	S	S		S	S	S			Length Class A Curves	Numeric; Decimal

Item No.	Required Sample Items									Data Item	Data Type
	Rural				Urban						
	Int	OPA	MA	MAC	Int	OFE	OPA	MA	Col		
64	S	S	S		S	S	S			Length Class B Curves	Numeric; Decimal
65	S	S	S		S	S	S			Length Class C Curves	Numeric; Decimal
66	S	S	S		S	S	S			Length Class D Curves	Numeric; Decimal
67	S	S	S		S	S	S			Length Class E Curves	Numeric; Decimal
68	S	S	S		S	S	S			Length Class F Curves	Numeric; Decimal
69				S						Horizontal Alignment Adequacy*	Software Calculated
70	S	S	S	S						Type of Terrain	Numeric; Codes
71				S						Vertical Alignment Adequacy*	Software Calculated
72	S	S	S		S	S	S			Length Class A Grades	Numeric; Decimal
73	S	S	S		S	S	S			Length Class B Grades	Numeric; Decimal
74	S	S	S		S	S	S			Length Class C Grades	Numeric; Decimal
75	S	S	S		S	S	S			Length Class D Grades	Numeric; Decimal
76	S	S	S		S	S	S			Length Class E Grades	Numeric; Decimal
77	S	S	S		S	S	S			Length Class F Grades	Numeric; Decimal
78	S	S	S	S						Percent Passing Sight Distance*	Numeric; Integer
TRAFFIC/CAPACITY											
79										Weighted Design Speed	Software Calculated
80	S	S	S	S	S	S	S	S	S	Speed Limit	Numeric; Integer
81	S	S	S	S	S	S	S	S	S	Percent Single Unit Trucks - Peak	Numeric; Integer
82	S	S	S	S	S	S	S	S	S	Percent Single Unit Trucks - Average Daily	Numeric; Integer
83	S	S	S	S	S	S	S	S	S	Percent Combination Trucks - Peak	Numeric; Integer
84	S	S	S	S	S	S	S	S	S	Percent Combination Trucks - Average Daily	Numeric; Integer
85	S	S	S	S	S	S	S	S	S	K-Factor	Numeric; Integer
86	S	S	S	S	S	S	S	S	S	Directional Factor	Numeric; Integer
87	S	S	S	S	S	S	S	S	S	Number of Peak Lanes	Numeric; Integer
88					S	S	S	S	S	Left Turning Lanes	Numeric; Codes
89					S	S	S	S	S	Right Turning Lanes	Numeric; Codes
90					S	S	S	S	S	Prevailing Type of Signalization	Numeric; Codes
91					S	S	S	S	S	Typical Peak Percent Green Time*	Numeric; Integer
92	S	S	S	S	S	S	S	S	S	Number At-Grade Intersections - Signals	Numeric; Integer
93	S	S	S	S	S	S	S	S	S	Number At-Grade Intersections - Stop Sign	Numeric; Integer
94	S	S	S	S	S	S	S	S	S	Number At-Grade Intersections - Other/No Control	Numeric; Integer
95	S	S	S	S	S	S	S	S	S	Peak Capacity	Software Calculated
96	S	S	S	S	S	S	S	S	S	Volume/Service Flow Ratio (V/SF)	Software Calculated
97	S	S	S	S	S	S	S	S	S	Future AADT	Numeric; Integer
98	S	S	S	S	S	S	S	S	S	Year of Future AADT	Numeric; Integer
End of sample data items.											

Key: A = Code for "All" universe, standard sample, and supplementary donut area sample sections.
S = Code for all "Standard" sample sections.
D = Code for all "Donut" area supplementary sample sections.
* = See individual data item for exceptions.

GENERAL CODING INSTRUCTIONS

Data items in the summary table are denoted in the Data Type column as having either “numeric” or "character" reporting specifications.

For numeric data items:

- leading zero must be coded in decimal value when the value is less than an integer (length = 0.21); otherwise, leading zeros are not required
- decimal points are required for all data items labeled "Numeric; Decimal," i.e., those reported in tenths, hundredths, or thousandths (PSR = 2.2; length = 10.252, etc.)
- one digit must be coded after a decimal point for all data items labeled "Numeric; Decimal"
- (PSR = 3 must be coded 3.0); additional trailing zeros are not required for the decimal portion
- when data is not available, code "0" or "0.0" as appropriate

For character data items:

- any alphanumeric character (A through Z; 0 through 9; space) may be coded
- do NOT use double quotes (") within the character string

For data items with assigned values (codes):

- select the appropriate value from the table
- the value must be coded precisely as listed in the table

DATA CODING INSTRUCTIONS

Item 1 — Year of Data (Numeric; Integer)
Enter the four digits of the calendar year for which the data apply. The HPMS software is "year 2000" compliant.

If adding a section while working in the HPMS software, the year will automatically be set based on the year in which the user is working. The year is displayed on top of the screen.

Item 2 — State Code (Numeric; Codes)
The State FIPS code is used in the HPMS database to identify the reporting State. Enter the State FIPS code as listed in Appendix A.

If adding a section while working in the HPMS software, the State code will automatically be coded based on the State selected. The State name is displayed on top of the screen.

Item 3 — Reporting Units - Metric or English (Numeric; Codes)
Code for all sections to indicate the units used to report measured and other measurement related data items. All data submitted to FHWA must be in metric units; the HPMS software will automatically convert all data to metric during the FHWA submit process. The same reporting unit must be used for all applicable data items for the entire data set. There can be no mixing of units within the data set.

Code	Description
0	Section data is coded using the English system of unit measurement (miles, feet, inches, etc.).
1	Section data is coded using the modernized metric system of unit measurement known as the SI (kilometers, meters, millimeters, etc.).

Most used **soft conversions**:

1 mile = 1.609344 kilometers	1 foot = 0.3048 meters = 304.8 millimeters
1 square mile = 2.59 square kilometers	1 inch = 0.0254 meters = 25.4 millimeters

Most used **hard conversions**:

11 foot lane = 3.3 meters	10 foot lane or shoulder = 3.0 meters
12 foot lane = 3.6 meters	55 mph = 90 km/h
8 foot shoulder = 2.4 meters	65 mph = 105 km/h

Reference: American Association of State Highway Transportation Officials (AASHTO) *Guide To Metric Conversion*, 1993

Hard conversion of data Items 54 (Lane Width); 59 and 60 (Shoulder Width); 79 (Weighted Design Speed); and 80 (Speed Limit) is preferred. A soft conversion for data Item 35, Measured Pavement Roughness, is provided in Appendix E as 63.36 inches/mile = 1.0 meter/kilometer.

HPMS conversion software is discussed in Appendix L; the software will perform the appropriate conversions of all of the applicable data items from English to Metric.

Item 4 — County Code (Numeric; Codes)
The FIPS county code permits analysis and mapping of information at a sub-State level. Enter the three-digit FIPS county code from FIPS Publication 6-4, *Counties and Equivalent Entities of the United States, Its Possessions, and Associated Areas*. Use county equivalents in HPMS for the following:

State	County Equivalent
Alaska	Highway Districts
Louisiana	Parishes
Puerto Rico	Municipio Districts

In the HPMS software, the County Names table must be kept current. To add a county, modify a county name, or delete a county code, select "Tools/County Names." When adding a section, the county code must be in the County Names table or the system will not allow the section to be added.

Item 5 — Section Identification (Character Field)
This item permits locating specific roadway section data within the HPMS database. This item must contain a 12-character countywide unique identifier. It provides flexibility to identify sections in accordance with a State's needs independent of the unique identifier that must be maintained for sample sections. This item may be defined to suit the needs of the State and may contain any right-justified alphanumeric character.

- For all individually reported sections (code "0" in item 9), supply a countywide unique section identifier. This may be a location specific identifier such as route kilometerpoint (milepoint), A-node/B-node, or a unique number.
- For highways reported as grouped sections (code "1" in Item 9), provide a countywide, unique group identifier. REMINDER: Only nonsample urban minor arterial, collector and local, and nonsample rural major and minor collector and local data can be grouped; NHS routes cannot be grouped regardless of functional system.

Examples:

1. **Section Identifier** (Item 9 = 0)
   Use any countywide unique identifier with no more than 12 "right justified" characters. An example using a location specific identifier:

Interstate Inventory Route 56, Kilometerpoint 4.321

Code	0	0	0	**I**	5	6	0	0	4	3	2	1

2. **Grouped Length** (Item 9 = 1)
   Use any countywide unique identifier - no limit on number of digits. An example using a unique number:

Grouped Length Record 98365

Code	0	0	0	0	0	0	0	9	8	3	6	5

Item 6 — Is Standard Sample (Numeric; Codes)
This data item is used by the software to indicate if a section is a standard sample.

Code	Description
0	Section **is not** a standard sample.
1	Section **is** a standard sample.

Item 7 — Is Donut Sample (Numeric; Codes)
This data item is used by the software to indicate if the section is a donut sample.

Code	Description
0	Section **is not** a donut sample.
1	Section **is** a donut sample.

If a section is:

- a universe section only, code "0" for both Items 6 and 7;
- both a standard sample and a donut sample, code "1" for both Items 6 and 7;
- a donut sample, code "0" for Item 6 and code "1" for Item 7;
- a standard sample, code "1" for Item 6 and code "0" for Item 7.

Item 8 — State Control Field (Character Field)
This is a data item of up to 100 alphanumeric characters for State use for identification or any other purpose. It may contain any keyboard characters; however, do not use binary zeros or double quotes. FHWA does not use this data item.

Item 9 — Is Section Grouped? (Numeric; Codes)
This item is used by the software to indicate whether the data reported are for a single section or for a group of sections.

Code	Description
0	Individual Section Data
1	Grouped Section Data

Use code "0" for all sections, including universe, standard sample, and supplementary donut area sample sections that are being reported on an individual section basis. Code "0" must be used for all principal arterial system (PAS), rural Minor Arterial, and NHS sections - grouping within these systems is not permitted.

Use the grouped length code "1" only when grouping homogeneous sections for reporting purposes; contiguous sections should not be reported as grouped sections. Only nonsample rural major collector, rural minor collector, rural local, nonsample urban minor arterial, nonsample urban collector, and urban local system sections not on the NHS can be grouped. Grouping may only be done when the data for Items 4; 13-17; 25-29; and 31-32 are homogeneous across all sections being grouped.

Item 10 — LRS Identification (Character Field)
This item, along with Items 11 and 12, permits users to reference HPMS information to the map location of road sections. Code for all PAS, NHS, and rural minor arterial system sections, in conjunction with LRS beginning and ending points (Items 11 and 12). More information concerning the LRS may be found in Chapter V, Linear Referencing System Requirements.

Inventory Route and Subroute Numbers for LRS Use:
The inventory route and subroute numbers reported in this item must be consistent with the inventory route and subroute numbers identified on the Inventory Route and Node Maps and in the Inventory Route Link Data File discussed in Chapter V, Linear Referencing System Requirements.

The inventory route number is a 10-character, right justified value. The LRS inventory route number can be alphanumeric, but must not contain blanks; leading zeros must be coded. The inventory route number is not necessarily the same as that posted along the roadway, but is a number used to uniquely identify a route within at least a county or, alternately, throughout the State. The inventory route number is followed by a 2-character numeric subroute number that uniquely identifies the AHEAD and BACK portions of an inventory route section where duplicate kilometerpoints (KMPTs) [milepoints (MPTs)] occur.

Example: Inventory Route 63951, Subroute Number 2

Code	0	0	0	0	0	6	3	9	5	1	0	2

Item 11 — LRS Beginning Point (Numeric; Decimal)
This item, along with Items 10 and 12, permits users to reference HPMS information to the map location of road sections. Code this item for all PAS, NHS, and rural minor arterial system section records for the purpose of establishing an LRS. This numeric item must be coded with the beginning KMPT (MPT) for the section on the inventory route and for the subroute number coded in the LRS Identification (Item 10).

The KMPT (MPT) for the section must be consistent with the LRS information found on the Inventory Route and Node Maps and in the Inventory Route Link Data File for a particular route and subroute. In order to be consistent, section breaks must adhere to the conditions listed in Chapter V, particularly under the section titled "Effects of LRS on HPMS Sections." See Chapter V for a full discussion on coding of the Linear Referencing System.

Code "0.0" for this item if LRS information is not provided. Code the beginning KMPT (MPT) to three decimal points. The KMPT (MPT) represents the distance in kilometers (miles) from a set reference point to the beginning of the highway segment and is the lowest KMPT (MPT) of the section.

The KMPT (MPT) numbering format should be such that the combination of county, inventory route number, subroute number, and KMPT (MPT) information will define a unique location.

Example: Beginning kilometerpoint 98.252 for the inventory route and subroute number coded in Item 10:

Code	9	8	.	2	5	2

Item 12 — LRS Ending Point (Numeric; Decimal)
This item, along with Items 10 and 11, permits users to reference HPMS information to the map location of road sections. Code this item for all PAS, NHS, and rural minor arterial system section records for the purpose of establishing an LRS. This numeric item must be coded with the ending KMPT (MPT) for the section on the inventory route and for the subroute number coded in the LRS Identification (Item 10).

The KMPT (MPT) for the section must be consistent with the LRS information found on the Inventory Route and Node Maps and in the Inventory Route Link Data File for a particular route and subroute. In order to be consistent, section breaks must adhere to the conditions listed in Chapter V, particularly under the section titled "Effects of LRS on HPMS Sections." See Chapter V for a full discussion on coding of the Linear Referencing System.

Code "0.0" for this item if LRS information is not provided. Code the ending KMPT (MPT) to three decimal points. The KMPT (MPT) represents the distance in kilometers (miles) from a set reference point to the end of the highway segment and is the highest KMPT (MPT) of the section.

The KMPT (MPT) numbering format should be such that the combination of county, inventory route number, subroute number, and KMPT (MPT) information will define a unique location.

Example: Ending kilometerpoint 101.206 for the inventory route and subroute number coded in Item 10:

Code	1	0	1	.	2	0	6

Item 13 — Rural/Urban Designation (Numeric; Codes)
This item permits analysis and mapping of information at a sub-State level. Code the value best describing the area.

Code	Description
1	Rural Area
2	Small Urban Area (Population 5,000 to 49,999)
3	Small Urbanized Area (Population 50,000 to 199,999)
4	Large Urbanized Area (Population 200,000 or More)

The FHWA-approved adjusted census urban boundary, including portions that cross State boundaries, is used to establish population criteria for coding this data item. July 1st estimates of population should be used as a base when determining the urbanized area size (code "3" or "4"). County level estimates are available by the end of each calendar year on the Internet at www.census.gov.

Item 14 — Urbanized Area Sampling Technique (Numeric; Integer)
This item is used by the software to calculate expansion factors. All urbanized areas that contain a population of 200,000 persons or more, or smaller urbanized areas that are within an NAAQS nonattainment

area boundary, or smaller urbanized areas that are NAAQS nonattainment areas on their own must be individually sampled. This includes any portion of a nonattainment urbanized area that crosses a State boundary, and individual State portions of an urbanized area that, in the aggregate (all States), contain more than 200,000 persons, even if the State's portion does not reach that population by itself. The State may retain existing grouped urbanized areas; however, in the future all urbanized areas must be individually sampled.

Code “0” for rural universe and standard sample sections and urban universe and standard sample sections that are located in urbanized areas, which are being individually sampled. For grouped urbanized areas, code universe and standard sample roadway sections as follows:

> If two or more areas are being grouped, one number, starting with “1,” should be used to identify the sections in each group. For example, if a State has consolidated all qualifying urbanized areas (<200,000 population and not an NAAQS nonattainment area) into one group, “1” should be coded for all sections in the group. If qualifying areas have been consolidated into two groups, sections in the first group of qualifying areas should be coded “1”, and those in the second group coded “2.” Sections in remaining individually sampled urbanized areas should be coded “0.”

Item 15 — Urbanized Area Code (Numeric; Codes)
This item permits analysis and mapping of information at the urbanized area level. Enter the numeric urbanized area code for sections within an urbanized area boundary when the Rural/Urban Designation (Item 13) is coded “3” or “4”. Otherwise, code “0.” Codes are included in Appendix B. Code for universe and standard sample sections only. Leading zeros are not required.

In the HPMS software, the Urbanized Area Names table must be kept current.

Item 16 — NAAQS Nonattainment Area Code (Numeric; Codes)
This item permits analysis and mapping of information for EPA designated nonattainment areas. Enter the numeric urbanized area code for the EPA-named NAAQS nonattainment area for all rural, small urban, and urbanized area universe, standard sample, and supplemental sample sections within the NAAQS nonattainment area boundary. When more than one urbanized area is within the nonattainment area boundary, enter the code for the most populous urbanized area. Leading zeros are not required.

Code “0” for sections that are not within a nonattainment area boundary, or if an NAAQS nonattainment area contains partial or split urbanized areas. Because the HPMS sample can represent only whole urbanized areas, expanded results are not legitimate for partial urbanized areas and HPMS cannot be used for travel tracking or other air quality purposes in these areas.

Urbanized area codes are included in Appendix B; assignment of NAAQS nonattainment area codes is discussed in Appendix G. The Houston nonattainment area coding example in Appendix G provides more explanation for coding this data item.

Item 17 — Functional System Code (Numeric; Codes)
This item permits analysis and mapping of information by highway functional system. Code the value that represents the functional system upon which the section is located.

Code	Description	Code	Description
RURAL		**URBAN**	
1	Principal Arterial - Interstate	11	Principal Arterial - Interstate
2	Principal Arterial - Other	12	Principal Arterial-Other Freeways & Expressways
6	Minor Arterial	14	Principal Arterial - Other
7	Major Collector	16	Minor Arterial
8	Minor Collector	17	Collector
9	Local	19	Local

Definitions of the highway functional systems can be found in Highway *Functional Classification, Concepts, Criteria and Procedures*, FHWA, March 1989.

Item 18 — Generated Functional System Code (Software Calculated)
This item is encoded by the HPMS software based on the Functional System (Item 17), and is used as a software aid. If Item 17 is changed, the standard calculations in the HPMS software package must be run to obtain the proper code in this field. The codes are as follows:

Code	Description	
RURAL		**URBAN**
1	Interstate	Interstate
2	Other Principal Arterial	Other Freeways and Expressways
3	Minor Arterial	Other Principal Arterial
4	Major Collector	Minor Arterial
5	Minor Collector	Collector
6	Local	Local

Item 19 — National Highway System (NHS) (Numeric; Codes)
This item, along with item 20, is used to track changes to the approved NHS, including intermodal connectors. Code this item for all sections to indicate whether the section is on the NHS or is an NHS connector to an intermodal facility. See the definition of NHS in Chapter II. Enter one of the following codes:

Code	Description	
0	This section **is not** on the NHS	
1	This section **is** on the NHS but **is not** an NHS intermodal connector	
2 - 9	This section **is** an NHS intermodal connector. Type of connector:	
	2	Major Airport
	3	Major Port Facility
	4	Major Amtrak Station
	5	Major Rail/Truck Terminal
	6	Major Intercity Bus Terminal
	7	Major Public Transit or Multi-Modal Passenger Terminal
	8	Major Pipeline Terminal
	9	Major Ferry Terminal
	If more than one connector type is involved, use the predominant type.	

Item 20 — Planned Unbuilt Facility (Numeric; Codes)
This item, along with item 19, is used to track changes to the approved NHS, including intermodal connectors. Code the status of the section being reported.

Code	Description
0	This roadway section **is not** on the NHS.
1	This roadway section **is on** the NHS and is open to public travel.
2	This roadway section **is on** the NHS but is not yet built.

For sections coded "0" or "1", code all applicable data items. For sections coded "2", report at least items 1-19 and 30, as applicable.

Item 21 — Official Interstate Route Number (Character Field)
This item, along with Items 22, 23, and 24, is used to track HPMS information by specific route. Code for all Interstate System sections using the officially approved AASHTO/FHWA Interstate route number. Enter a 5-character, right justified, alphanumeric value for the Interstate System route number. If two or more Interstate routes occupy the same roadway, code the lowest official route number. If the route is not an official Interstate route, leave blank or zero-fill, regardless of signing.

Alaska, Hawaii, and Puerto Rico may use alpha characters in the Interstate route number field as part of the official AASHTO/FHWA route number. Other exceptions include coding for Interstate routes with parallel or diverging branches having cardinal direction letters in the official route number; for example, Interstate Route 35 in Minnesota splits with 35E going through St. Paul and 35W through Minneapolis.

Item 22 — Route Signing (Numeric; Codes)
This item, along with Items 21, 23, and 24, is used to track HPMS information by specific route. Code for all PAS, NHS, and rural minor arterial system sections. Reporting for other systems is optional. Code the value which best represents the manner in which the highway segment is signed with route markers. If the roadway is unsigned, use code "0."

Code	Description	Code	Description
0	Not Signed or Not Applicable	5	County
1	Interstate	6	Township
2	U.S.	7	Municipal
3	State	8	Parkway Marker or Forest Route Marker
4	Off-Interstate Business Marker	9	None of the Above

When a section is signed with two or more identifiers (i.e., Interstate 83 and U.S. 32), code the highest class of route (Interstate in this example). Follow the hierarchy as ordered above.

Item 23 — Route Signing Qualifier (Numeric; Codes)
This item, along with Items 21, 22, and 24, is used to track HPMS information by specific route. Code for all PAS, NHS, and rural minor arterial system sections. Reporting for other systems is optional. Code the value which best represents the manner in which the highway segment is signed on the route marker described in Item 22. Where more than one code is applicable, use the lower code. If the roadway is unsigned, use code "0."

Code	Description	Code	Description
0	No Qualifier or Not Signed or Not Applicable	5	Loop
1	Alternate	6	Proposed
2	Business Route	7	Temporary
3	Bypass	8	Truck Route
4	Spur	9	None of the Above

Item 24 — Signed Route Number (Character Field)
This item, along with Items 21, 22, and 23, is used to track HPMS information by specific route. Code for all PAS, NHS, and rural minor arterial system sections. Reporting for other systems is optional. Enter an 8-character, right-justified, alphanumeric value for the signed route number shown on the marker described in Items 22 and 23. If two or more routes of the same class in the hierarchy are signed along a roadway section (i.e., Interstate 64 and Interstate 81), code the lowest route number (Interstate 64 in this

example). If Items 22 or 23 are coded "9," code other descriptive alphabetic character prefixes or suffixes abbreviated to 8 characters if available. If Item 22 is coded "0," leave blank or zero-fill.

Item 25 — Governmental Ownership (Numeric; Codes)
This item identifies the road owner and is used in cost allocation studies, to track historic data, and in the national highway database. Code the level of government that best represents the highway owner irrespective of whether agreements exist for maintenance or other purposes. The purpose of this item is to identify the owner of public roads; do not include privately owned roads in HPMS. If more than one code applies, code the lowest numerical value.

Code	Description	Code	Description
1	State Highway Agency	5	Other State Agency
2	County Highway Agency	6	Other Local Agency
3	Town or Township Highway Agency	7	Federal Agency
4	Municipal Highway Agency	8	Other

For purposes of this data item:

"**State**" means owned by one of the 50 States, the District of Columbia, or the Commonwealth of Puerto Rico including quasi-official State commissions or organizations;

"**County, local, municipal, town, or township**" means owned by one of the officially recognized governments established under State authority;

"**Federal**" means owned by one of the branches of the U.S. Government or independent establishments, government corporations, quasi-official agencies, organizations, or instrumentalities;

"**Other**" means owned by tribal Nations, or nongovernmental organizations with the authority to build, operate, or maintain toll or free highway facilities.

Item 26 — Special Systems (Numeric; Codes)
This item is used to track changes to the STRAHNET and is used by the Department of Defense (DOD) to identify strategic deployment routes. Code whether an open-to-traffic section is on the STRAHNET or a STRAHNET connector (see definition in Chapter 2). Code all open-to-traffic Interstate System sections "1."

Code	Description
0	Section **is not** on STRAHNET or a STRAHNET connector
1	Section **is** on STRAHNET or a STRAHNET connector

Item 27 — Type of Facility (Numeric; Codes)
This item is used to determine whether a roadway or structure is a one- or two-way operation. It is used in investment requirements modeling to calculate capacity and estimate roadway deficiencies and improvement needs, in the cost allocation pavement model, and in the national highway database.

Code	Description
1	One-Way Roadway
2	Two-Way Roadway
3	One-Way Structure (Bridge, Tunnel, Causeway, etc.)
4	Two-Way Structure (Bridge, Tunnel, Causeway, etc.)

Use code "1" or "2" as applicable except when the section being reported is **entirely** on a structure.

One-Way: A roadway or structure section with traffic moving in only one direction during non-peak period hours. When part of a one-way couplet, report each roadway/structure section independently.

Two-Way: A roadway or structure with traffic moving in both directions during non-peak period hours.

Item 28 — Designated Truck Route (Numeric; Codes)
This item is used in truck size and weight studies as an administrative identifier to determine whether a section is on or off a truck route designated under Federal regulatory authority. Code this item for all sections.

Code	Description
0	Not on a designated truck route
1	Designated truck route under **Federal authority** in 23 CFR 658.

Designated truck routes (code "1") are those routes that are available to truck tractor and 14.63-meter (48-foot), or longer if "grandfathered", semi trailer combinations, truck tractor and 8.53-meter (28-foot) twin trailer combinations, both subject to no overall length limits, and specialized combination vehicles such as automobile and boat transporters, maxicube vehicles, and saddle mount combinations, subject to Federal minimum overall length limits [generally 19.81 to 22.86 meters (65 to 75 feet)], all of which may be up to 2.59 meters (102 inches) wide.

Designated truck routes, shown in Appendix A to 23 CFR 658, are open to vehicles subject to Federal minimum length limits specified in Section 411 of the Surface Transportation Assistance Act (STAA) of 1982 and the Federal width limit of 2.59 meters (102 inches) specified in Section 416 of STAA. Additional routes for such vehicles may have been designated under State authority.

Do not include the following as designated truck routes for the purposes of this data item (use code "0"):

a. Routes (or portions thereof) that simply provide "access" for these large vehicles to terminals and for food, fuel, repair, or rest services.
b. Those routes designated only under State authority that restrict some of the trucks described above because of length or width limitations or because of time of day restrictions.

Item 29 — Toll (Numeric; Codes)
This item is used as an administrative identifier to determine whether a section is on or off a toll road. Toll data are also used for historic trends, policy analysis, and legislation development purposes. Code this item for all sections.

Code	Description
0	Section is non-Toll
1	Section is Toll

In general, code a section as toll if a fee is charged for its use. If portions of a contiguous facility can be traversed without the payment of a toll, but a toll is charged on other portions, code the entire contiguous facility as toll. This applies even if some vehicles can enter and exit from the main through route without payment of a toll. If a toll is charged in only one direction, the "free" direction is also considered to be toll. Code a facility operated by a toll authority upon which no toll is charged as non-toll.

Item 30 — Section Length (Numeric; Decimal)
This item provides basic inventory information on the amount of public roads. It is extensively used for

apportionment, administrative, legislative, analytical, and national highway database purposes. Code this numeric data item for all sections. Report length, in kilometers (miles), as measured along the centerline of the roadway. If the state has chosen an inventory direction for data reporting on divided facilities, the length is as measured along the centerline of the inventory direction. On independently aligned, divided highways, centerline length also may be reported as the average of the lengths of the directional roadways, measured along their center lines. Report the length of the two roadways of a one-way couplet independently; do not average.

When measuring length between at-grade route intersections, use the actual center of the intersection as the point of measurement (Figure IV-1). If grade separated, measure to the theoretical center of the intersecting roadways. When a route terminates at a tee interchange, measure the length as the average of the four directional, connecting ramp lengths to the first point of intersection with the other mainline route (Figure IV-2). In all other situations, ramps are considered part of the mainline routes and their length is not reported for HPMS purposes.

When grouping homogeneous nonsample roadways (see Items 5 and 9), code the total combined length of the grouped sections. Code length to the nearest thousandth, although measurements may reflect the precision normally utilized by the State. Minimal measurement precision to at least the nearest tenth kilometer (mile) is requested. **Length cannot be zero-coded**.

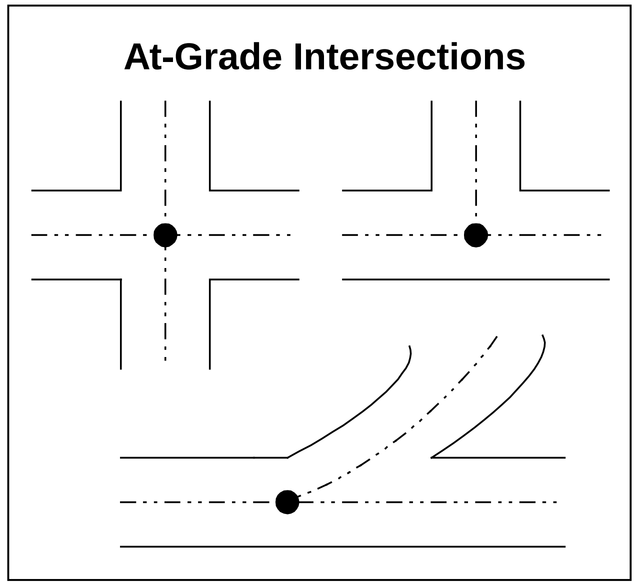


Figure IV-1. Two-Way At-Grade Intersections.
Length is measured to the midpoint of the roadways.

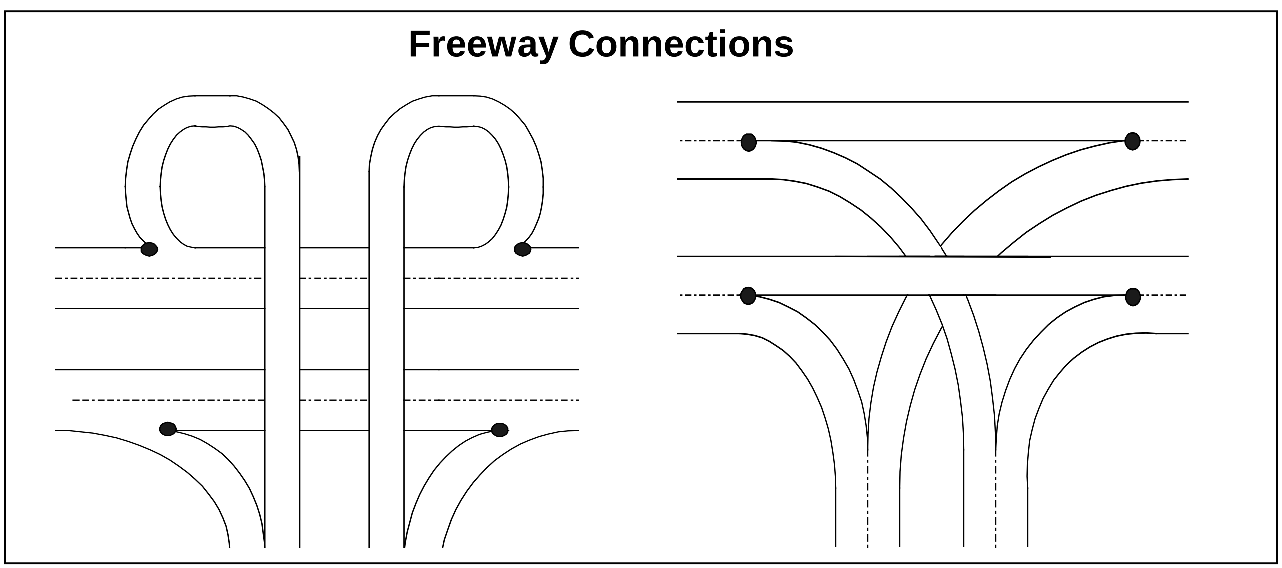


Figure IV-2. Freeway Tee Intersection.
Length is an average of the four connectors (Ramps) measured to the gore points.

Item 31 — Donut Area Sample AADT Volume Group Identifier (Numeric; Integer)
This item is used to identify the AADT volume group for a section when an actual AADT is not reported in Item 33. Code a donut area sample volume group number (valid codes 1-5) for the section when an AADT is not coded in Item 33; when an AADT is coded, the HPMS software will assign the volume group number if the State is using the FHWA volume group ranges. The AADT or volume group must be coded for applicable universe, standard sample, and donut area supplementary sample sections for the rural minor arterial and major collector, and the small urban minor arterial and collector functional systems that are within the donut area portion of a nonattainment area. Code "0" for all other sections. The AADT ranges for each volume group number are shown in Appendix C, Table C-5.

When AADT is not known, use traffic flow maps, count data obtained from local governments, and other available data to make reasonable volume group assignments.

A discussion of NAAQS nonattainment and donut areas and a description of the donut area sampling scheme is contained in Appendix G.

Item 32 — Standard Sample AADT Volume Group Identifier (Numeric; Integer)
This item is used to identify the AADT volume group for a section when an actual AADT is not reported in Item 33. Code a standard sample volume group number (valid codes 1-13) for the section when an AADT is not coded in Item 33; when an AADT is coded, the HPMS software will assign the volume group number if the State is using the FHWA volume group ranges. An AADT or the volume group must be coded for applicable universe, standard sample, and donut area supplementary sample sections for all except the rural minor collector and the rural and urban local functional systems. Code "0" for all other sections. The AADT ranges for each volume group number are shown in Appendix C, Tables C-1 to C-4.

When AADT is not known, use traffic flow maps, count data obtained from local governments, and other available data to make reasonable volume group assignments.

A description of the standard sampling scheme is contained in Chapter VII.

Item 33 — Annual Average Daily Traffic (AADT) (Numeric; Integer)
This item provides basic existing traffic inventory information for selected sections. It is extensively used for apportionment, administrative, legislative, analytical, and national highway database purposes. Code this numeric data item for all PAS, NHS, standard sample, and donut area supplementary sample sections; leading zeros are not required. Coding is optional for remaining sections. Code "0" when AADT is not coded.

Enter the section AADT for the data year. For two-way facilities, provide the AADT for both directions; provide the directional AADT if part of a one-way couplet or for one-way streets. Since many applications, including travel estimates, are based on section AADTs, States should provide AADT values that are count-based (actual counts adjusted to represent AADT) rather than estimated values.

Update reported AADT values annually. All counts must reflect application of day of week, seasonal, and axle correction factors, as necessary. Growth factors must be applied if the AADT is not derived from current year counts. Specific guidance for the frequency and size of traffic data collection programs, factor development, age of data, and other applications is contained in Appendix F and the *Traffic Monitoring Guide*.

REMINDER: Metropolitan planning organizations and other local governmental agencies may use an average weekday traffic volume for local purposes. The HPMS requires reported AADT to be an average daily value that represents all days of the reporting year.

Item 34 — Number of Through Lanes (Numeric; Integer)
This item provides basic inventory information on the amount of public road supply. It is extensively used for apportionment, administrative, legislative, analytical, and national highway database purposes. Code this numeric data item for all HPMS sections except those on the rural minor collector and the rural and urban local functional systems; leading zeros are not required. Code "0" when data not provided.

Code the number of through lanes according to the striping, if present, on multilane facilities, or according to traffic use or State/local design guidelines if no striping or only centerline striping is present.

Enter the prevailing number of through lanes in both directions carrying through traffic in the off-peak period (Figure IV-3). Exclude what are defined as auxiliary lanes, such as collector-distributor lanes, weaving lanes, frontage road lanes, parking and turning lanes, acceleration/deceleration lanes, toll collection lanes and truck climbing lanes. See the *AASHTO Design Guide* for additional information on auxiliary lanes.

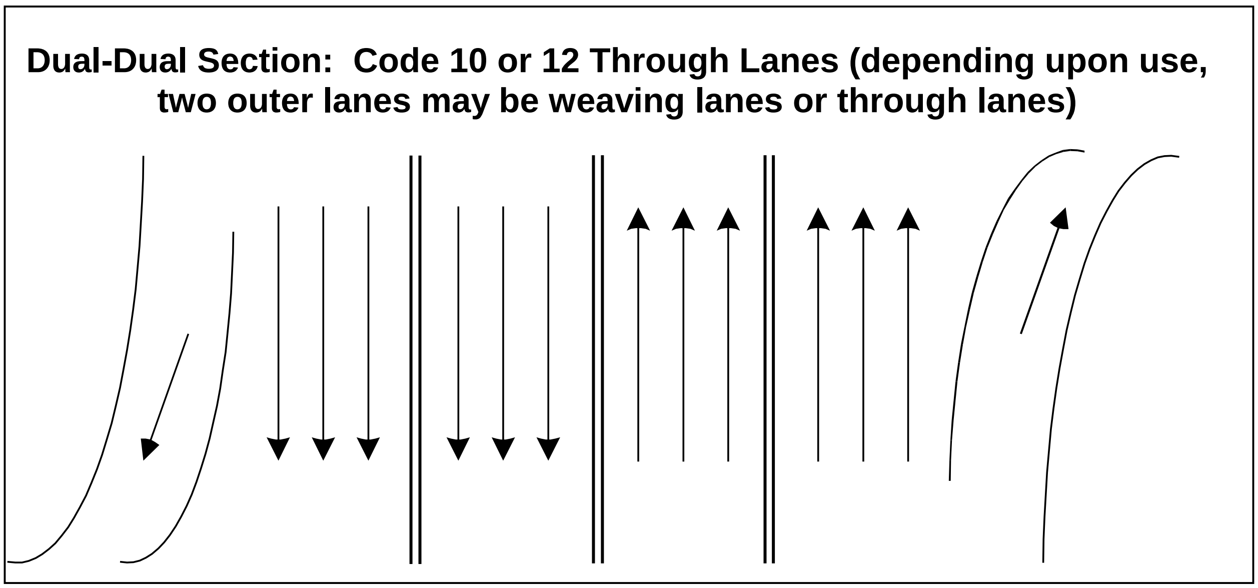


Figure IV-3. Number of Through Lanes

Item 35 — Measured Pavement Roughness (IRI) (Numeric; Decimal)
This item provides information on pavement surface roughness on selected roadway sections. It is used in investment requirements modeling to estimate pavement deterioration, section deficiencies, and needed improvements, in cost allocation studies, in pavement condition trends, and for other analysis purposes including NHS performance. Code the International Roughness Index (IRI) for paved sections in accordance with minimum reporting specifications contained in Table IV-3; IRI is required for all NHS sections regardless of functional system. IRI should be remeasured in the field on a two-year cycle; however, retain existing IRI values for sections until they are replaced by new measured values.

Table IV-3. Roughness Reporting Requirements

Functional System	Section Type	Roughness
RURAL		
Interstate	All Sections	Required
Other Principal Arterial	All Sections	Required
Minor Arterial	Standard Sample	Required
Major Collector	Standard Sample	Recommended
URBAN		
Interstate	All Sections	Required
Other Freeways & Expressways	All Sections	Required
Other Principal Arterial	All Sections	Required
Minor Arterial	Standard Sample	Recommended
Collector	Standard Sample	Recommended

Enter the measured IRI value to the nearest unit per length measurement, hundredths of meters/kilometer (x.xx) for the Metric system or whole inches/mile (x.0) for the English system. The entry must be in accordance with the reporting units chosen for Metric (or English) Reporting Units (Item 3). Code “0.0” for unpaved facilities and for sections for which IRI data are not provided.

Default values or values obtained by other means or conversions that are not directly obtained from measured road profiles are not to be used. However, when a pavement improvement is made on an applicable section, a temporary value for the improved section reflecting a reasonable average value for new pavement may be provided until replaced by a measured value. States are encouraged to use data from State or local pavement management systems when they are available, are current, and when they meet HPMS reporting requirements.

A PSR value is required for those standard sample sections where an IRI value is not reported. If a measured IRI value is reported for a section, a PSR value for that section is not required. **A standard sample section must have either PSR or IRI reported**.

FHWA has adopted AASHTO Provisional Standard PP37-99 as the preferred method of providing IRI data for the HPMS. Appendix E contains the AASHTO provisional standard along with recommended additional good practice guidelines and data collection procedures.

Item 36 — Present Serviceability Rating (PSR) (Numeric; Decimal)
This item provides information on pavement condition on selected roadway sections. It is used in investment requirements modeling to estimate pavement deterioration, section deficiencies, and needed improvements, in the cost allocation pavement model, and for national highway database purposes. Code a PSR or equivalent value, to the nearest tenth (x.x), for all paved standard sample sections where Item 35, Measured Pavement Roughness, is not reported. Code “0.0” for unpaved facilities and for sections for which PSR data are not provided. Code PSR or the Present Serviceability Index (PSI) where available. If sufficiency ratings of pavement condition are available, they may be used after a correlation between the sufficiency rating scale and the PSR scale or other rating factors is developed.

If there are no current PSR, PSI, or sufficiency ratings that can be adapted, the section can be rated using values in Table IV-4. Estimates to the nearest tenth within the applicable range should be made, e.g., 2.3. Where different lanes have different pavement condition ratings, code the worst condition.

If IRI is reported for a section, then PSR for that section is not required to be reported. **A standard sample section must have either PSR or IRI reported**.

Table IV-4. Pavement Condition Rating (Use full range of values)

PSR	Description
4.0 - 5.0	Only new (or nearly new) superior pavements are likely to be smooth enough and distress free (sufficiently free of cracks and patches) to qualify for this category. Most pavements constructed or resurfaced during the data year would normally be rated in this category.
3.0 - 4.0	Pavements in this category, although not quite as smooth as those described above, give a first class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling.
2.0 - 3.0	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and extensive patching. Rigid pavements in this group may have a few joint failures, faulting and/or cracking, and some pumping.
1.0 - 2.0	Pavements in this category have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement may have large potholes and deep cracks. Distress includes raveling, cracking, rutting and occurs over 50 percent of the surface. Rigid pavement distress includes joint spalling, patching, cracking, scaling, and may include pumping and faulting.
0.0 - 1.0	Pavements in this category are in an extremely deteriorated condition. The facility is passable only at reduced speeds, and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.

Item 37 — High Occupancy Vehicle (HOV) Operations (Numeric; Codes)
This item is used to identify those roadway sections with HOV operations. Code this data item for all sections to best reflect the nature of existing HOV operations.

Code	Description
0	Section does not have HOV lanes
1	Section has exclusive HOV lanes (HOV use only; no other uses permitted)
2	Normal through lane(s) used for exclusive HOV in specified time periods
3	Shoulder/parking lane(s) used for exclusive HOV in specified time periods

Items 38-46 — Highway Surveillance Systems (Numeric; Codes)
These items are used to track the deployment of ITS surveillance technologies. Code these data items to best describe the nature of existing surveillance systems. Enter the appropriate code for “yes” or “no” to describe the surveillance systems. If the surveillance system affects the operation of the roadway, code this data item even if the system does not actually exist on the section (i.e., variable message signs may be mounted every few miles, but the whole roadway is affected from the first such sign to the last; all sections in between should contain the “yes” code).

Item	No	Yes	Description
38	0	1	Section is under electronic surveillance to collect real time traffic data to monitor traffic flow.
39	0	1	Section has metered entrance ramps.
40	0	1	Section is covered by permanent variable message signs.
41	0	1	Section is covered by highway advisory radio.
42	0	1	Section is covered by surveillance cameras.
43	0	1	Section is covered by incident detection technology algorithms.
44	0	1	Section is covered by free cell phone to dedicated number other than 911, statewide DUI, etc.
45	0	1	Section is covered by publicly sponsored on-call service patrol or towing service.
46	0	1	Section has hardware needed to provide in-vehicle signing information to equipped vehicles.

Item 47 — Sample Identifier (Character Field)
The sample identifier is a statewide or countywide unique 12-character alphanumeric code that cannot change once it has been assigned. It is used to track standard and supplementary sample sections over time, and must never change for any reason. For existing sections, carry over the sample identifier from year to year. For a new sample section, assign a new, unique sample identifier. When an existing sample is split, assign the existing sample identifier to the section retained as the HPMS sample; see Chapter VII for a further discussion of sample splitting.

The State may change the Section Identification (Item 5) if necessary; the State Control Field (Item 8) should be used for additional State required identifiers.

Item 48 — Donut Area Sample Expansion Factor (Software Calculated)
Expansion factors are used to expand sampled data to represent the universe from which the sample is drawn. This value is calculated and coded to the donut area sample section by the HPMS software using the volume group information in Item 31. By definition, the expansion factor is the ratio of the total length in a volume group to the total sampled volume group length:

$$\text{Expansion Factor} = \frac{\text{Total length in the Volume Group}}{\text{Sampled length in the Volume Group}}$$

If the expansion factor for a volume group exceeds 100.000, select additional sample sections from the universe volume group until the expansion factor is reduced to a maximum of 100.000. If there are fewer than three samples in a volume group and additional universe sections are available, select additional samples from the universe volume group.

Appendix G contains a discussion of travel estimate requirements for the donut area portion of NAAQS nonattainment areas and describes the donut area sample selection and maintenance scheme.

Item 49 — Standard Sample Expansion Factor (Software Calculated)
Expansion factors are used to expand sampled data to represent the universe from which the sample is drawn. This value item is calculated and coded to the standard sample section by the HPMS software using the volume group information in Item 32. By definition, the expansion factor is the ratio of the total length in a volume group to the total sampled volume group length:

$$\text{Expansion Factor} = \frac{\text{Total length in the Volume Group}}{\text{Sampled length in the Volume Group}}$$

If the expansion factor for a volume group exceeds 100.000, select additional sample sections from the universe volume group until the expansion factor is reduced to a maximum of 100.000. If there are fewer than three samples in a volume group and additional universe sections are available, select additional samples from the universe volume group.

Chapter VII contains a description of the standard sample selection and maintenance scheme.

Item 50 — Surface/Pavement Type (Numeric; Codes)
This item details the type of pavement surface on sample roadway sections. It is used in investment requirements modeling to estimate pavement deterioration and loading history, for the cost allocation pavement model, and for the national highway database. Enter the code which best represents the type of surface on the section.

Code	Description
1	Road is unpaved.
2	Low type bituminous surface-treated—a bituminous surface course with or without a seal coat, the total compacted thickness of which is less than 25 millimeters (1 inch). Seal coats include those known as chip seals, drag seals, plant-mix seals, and rock asphalt seals.
3	Intermediate type mixed bituminous or bituminous penetration surface—a surface course 25 millimeters (1 inch) or greater and less than 178 millimeters (7 inches) in compacted thickness composed of gravel, stone, sand or similar material, and mixed with bituminous material under partial control as to grading and proportions or bound with bituminous penetration material.
4	High type flexible—mixed bituminous or bituminous penetration road on a flexible base with a combined surface and base thickness of 178 millimeters (7 inches) or more. Includes any bituminous concrete, sheet asphalt, or rock asphalt having a high load-bearing capacity. Includes any brick, stone, wood, or steel block pavement with or without a wearing surface of less than 25 millimeters (1 inch).
5	High type rigid—Portland cement concrete (PCC) pavement with or without joints; with or without mesh or similar reinforcement. Includes continuously reinforced PCC pavement, PCC pavement over a PCC pavement, either bonded, unbonded, or partially bonded, and PCC pavement over a bituminous pavement, either mixed or penetration.
6	High type composite—mixed bituminous or bituminous penetration road on a rigid pavement with a combined surface and base thickness of 178 millimeters (7 inches) or more. Includes any bituminous concrete, sheet asphalt or rock asphalt overlay of rigid pavement that is greater than 25 millimeters (1 inch) of compacted bituminous material; otherwise use code "5."

Item 51 — SN or D (Numeric; Decimal)
This item provides specific information about the pavement section in terms of structural number [SN] for flexible pavement or thickness (depth) [D] for rigid pavement on sample roadway sections. It is used in investment requirements modeling to estimate pavement deterioration and loading history and in the cost allocation pavement model. Code this numeric item for all standard sample sections. Enter SN to the nearest tenth (xx.x) and D to the nearest whole millimeter or inch (xx.0). When known, enter the actual value; otherwise code a typical value for the functional system and pavement type based upon historic data or State practice. The SN or D value should reflect the last improvement on the section. That is, when an improvement is made, take all new or redesigned base and pavement materials into consideration when determining the appropriate value.

Code SN or D consistent with the reporting units chosen for Metric (or English) Reporting Units (Item 3). Calculate SN (a unitless number) such that the layer coefficients [value per millimeter (inch)] and the layer thicknesses [millimeters (inches)] are in the appropriate reporting unit system.

Item 52 — General Climate Zone (Software Set)
This item is a calculated value locating the sample section in one of nine climate zones. It is used in the cost allocation pavement model. This numeric item is coded by the HPMS software from county/climate zone equivalency tables. It should be checked and may be changed if found not to be representative of the area in question. If the county code is changed, the climate zone should be updated using the HPMS calculation software. The definitions for the nine climate zones are included in Appendix I.

Item 53 — Year of Surface Improvement (Numeric; Integer)
This item is used to identify the year in which the sample section roadway surface was last improved. It is used in the cost allocation pavement model to deteriorate pavement condition. Enter the 4-digit year when the last surface improvement was completed on the section. Retain the coded improvement year in this data item until another improvement affecting the surface is completed. Code "0" if the section has not been improved since the initial reporting year (1988). Include post 1987 improvements on newly selected sample sections. Twenty-five millimeters (one inch) or more of compacted pavement material must be put in place for it to be considered a surface improvement for HPMS purposes.

Item 54 — Lane Width (Numeric; Decimal)
This item is a measure of existing lane width on sample roadway sections. It is used in investment requirements modeling to calculate capacity, estimate needed improvements, and compute a safety index, for cost allocation pavement models, and for other policy analysis and national highway data base purposes. Enter the prevailing through lane width to the nearest tenth of a meter (x.x) or whole foot (x.0). Code according to the reporting units chosen for Metric (or English) Reporting Units (Item 3).

Lane width should be coded according to where the pavement/shoulder surface changes, or to the pavement lane striping if the shoulder and pavement surface are the same, or according to traffic use or State/local design guidelines if no striping or only centerline striping is present. For example, the number of through lanes in Figure IV-4 would probably be 2; deducting 3 meters (10 feet) for parking on each side would leave width for two 5.5 meter (18 foot) lanes. Number of through lanes (Item 34) and lane width would be coded accordingly.

Where there is no delineation between the through traffic lane and the shoulder or parking lane, or where there is no centerline, estimate a reasonable split between the actual width used by traffic and the shoulder or parking lane based on State/local design guides.

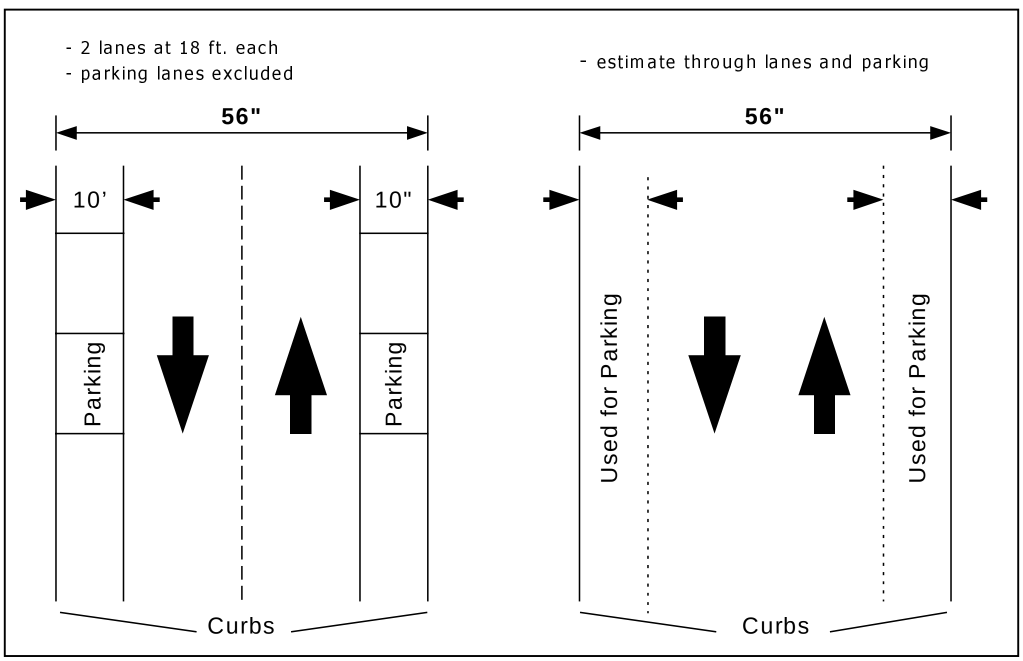


Figure IV-4. Lane Width

Item 55 — Access Control (Numeric; Codes)

This item is a measure of the degree of access control on sample roadway sections. It is used in investment requirements modeling to calculate capacity and estimate type of design, in truck size and weight studies, and for national highway data base purposes. Code the type of access control for all standard sample sections.

Code	Description
1	**Full Access Control**: Preference given to through traffic movements by providing interchanges with selected public roads and by prohibiting crossing at grade and direct driveway connections.
2	**Partial Access Control**: Preference given to through traffic movement. In addition to interchanges, there may be some crossings at-grade with public roads, but direct private driveway connections have been minimized through the use of frontage roads or other local access restrictions. Control of curb cuts is not access control.
3	**No Access Control**: Include all sections that do not meet the criteria above.

Item 56 — Median Type (Numeric; Codes)

This item is a characterization of the type of median on sample roadway sections. It is used in investment requirements modeling to calculate capacity and estimate type of design and for national highway data base purposes. Code the type of median for all standard sample sections.

Code	Description
1	Curbed
2	Positive Barrier
3	Unprotected
4	None

A positive barrier normally consists of a guardrail or concrete barrier, but could consist of thick, impenetrable vegetation. Turning lanes or bays are not considered medians unless the turning lanes/bays are cut into an existing median at intersections, entrance drives, etc; a continuous turning lane is not a median. Use code “3” if an unprotected median is at least 1.2 meters (4 feet) wide; otherwise, use code “4,” None.

Item 57 — Median Width (Numeric; Decimal)
This item is a measure of existing median width on sample roadway sections. It is used in investment requirements modeling to calculate capacity and estimate type of design and for national highway data base purposes. Code the median width for all standard sample sections. Code according to the reporting units chosen for Metric (or English) Reporting Units (Item 3).

Enter the predominant median width including left shoulders, if any, measured between the inside edges of the through lanes, to a tenth of a meter (x.x) or the nearest foot (x.0). Enter "0.0" where Item 56 is coded "4." Enter "999.9" where the median width is 30 meters or 100 feet or greater. Ignore turning bays cut into the median. See Figure IV-5.

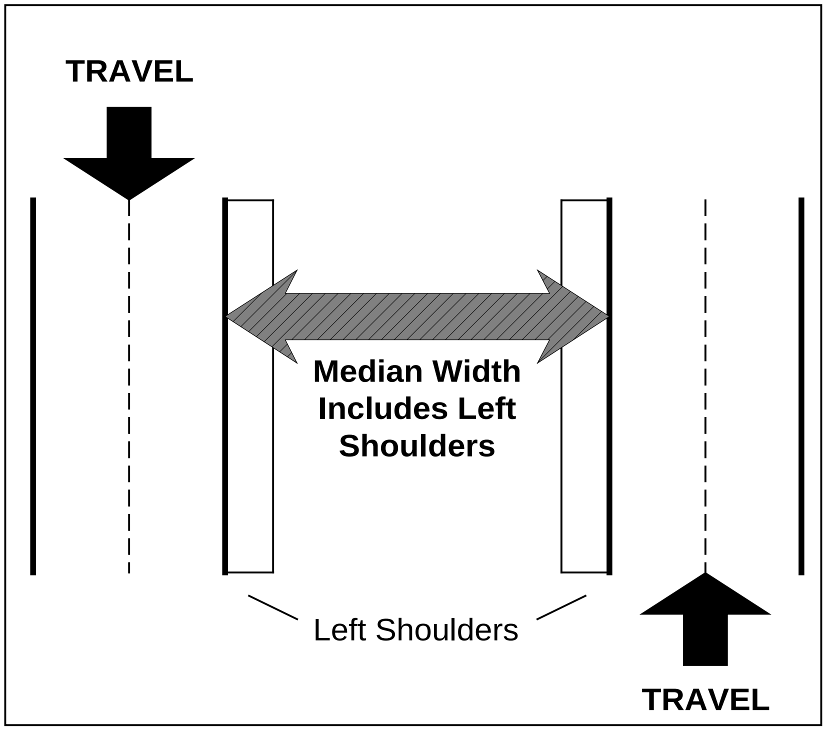


Figure IV-5. Median Measurement.

Item 58 — Shoulder Type (Numeric; Codes)
This item provides information on the type of existing shoulders on sample roadway sections. It is used in investment requirements modeling to estimate needed improvements. Enter the code for the type of shoulder on the section. If the shoulder type changes back and forth along the length of the section, code the predominant type. If left and right shoulder types differ on a divided facility, code the right shoulder type as the predominant type. If there is a shoulder in front of a barrier curb, code the shoulder type and width, but do not code as a shoulder the area behind a barrier curb. Ignore mountable curbs for reporting purposes; if there is a shoulder either in front of or behind a mountable curb, code the shoulder type and width. If the section has parking abutting the through lane, there cannot be a shoulder; if a bike lane abuts the through lane, there cannot be a shoulder unless it is a combined shoulder/bike lane. If there is parking on one side of a divided roadway and a shoulder or a curb on the other side, code both parking and shoulder type and width accordingly. A shoulder cannot exist between a traffic lane and a parking lane. If a bike lane or parking is completely separated from the roadway, it should not be considered.

Code	Description
1	None: No shoulders or curbs exist.
2	Surfaced shoulder exists (bituminous concrete or Portland cement concrete surface).
3	Stabilized shoulder exists (stabilized gravel or other granular material with or without admixture).
4	Combination shoulder exists (shoulder width has two or more surface types; for instance, part of the shoulder width is surfaced and a part of the width is earth, etc.).
5	Earth shoulder exists.
6	Barrier curb exists; no shoulders in front of curb.

Item 59 — Right Shoulder Width (Numeric; Decimal)
This item measures the existing shoulder width on sample roadway sections. It is used in investment requirements modeling to calculate capacity and estimate needed improvements. Enter the width of the right shoulder to the nearest tenth of a meter (x.x) or whole foot (x.0). Code "0.0" if no right shoulder exists. Refer to Item 58 and Figures IV-6A-C for additional coding details. Do not include parking or bicycle lanes in the shoulder width measurement; code the predominant width where it changes back and forth along a roadway section; ensure that the total width of combination shoulders is reported. Include rumble strips and gutter pans in shoulder width.

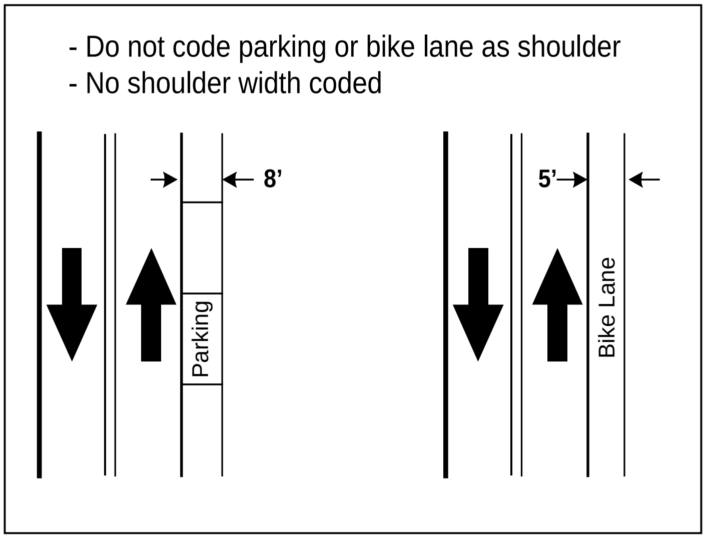


Figure IV-6A. Shoulder Type/Width

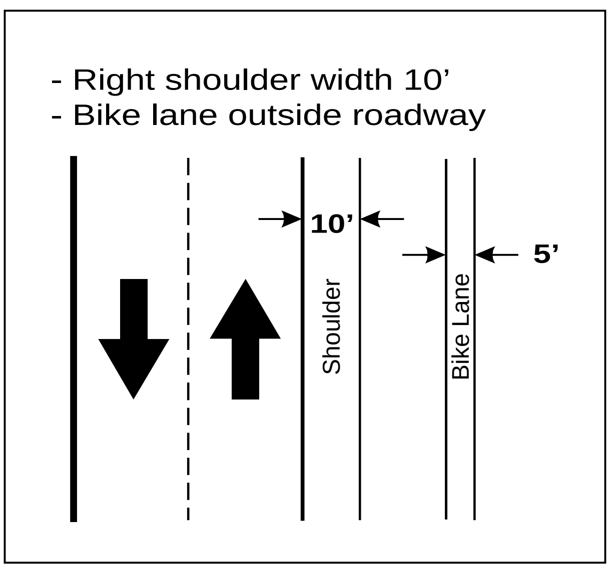


Figure IV-6B. Shoulder Type/Width

Item 60 — Left Shoulder Width (Numeric; Decimal)
This item measures the existing shoulder width on sample roadway sections. It is used in investment requirements modeling to calculate capacity and estimate needed improvements. On divided highways, enter the width of the left (median) shoulder to the nearest tenth of a meter (x.x) or whole foot (x.0). Code "0.0" where no left shoulder exists or if the section is undivided. Refer to Item 58 and Figures IV-6A-C for additional coding details. Do not include parking or bicycle lanes in the shoulder width measurement; code the predominant width where it changes back and forth along a roadway section; ensure that the total width of combination shoulders is reported. Include rumble strips and gutter pans in shoulder width.

Item 61 — Peak Parking (Urban Data Item) (Numeric; Codes)
This item provides specific information about the presence of peak parking on urban sample roadway sections. It is used in investment requirements modeling to calculate capacity on sections with signals. Enter the code that best reflects the type of peak parking that exists on the section. Code to reflect permitted use; code permitted parking even if the section is not formally signed or striped for parking. If parking is actually beyond the shoulder or the pavement edge where there is no shoulder, use code "3" for no parking. If parking lanes are legally used for through traffic or turning lanes during the peak-hour, code the appropriate in-use condition.

Code	Description
0	Not Applicable; Section is Rural
1	Parking Allowed One Side
2	Parking Allowed Both Sides
3	No Parking Allowed or None Available

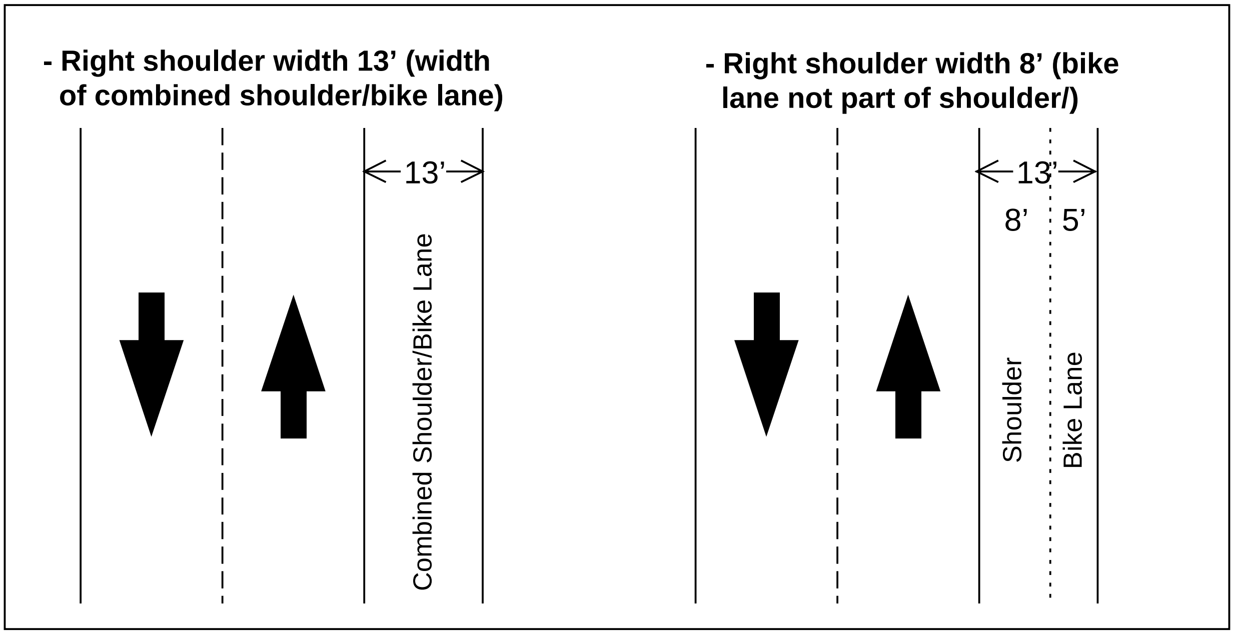


Figure IV-6C. Shoulder Type/Width

Item 62 — Widening Feasibility (Numeric; Codes)
This item provides a measure of whether it is feasible to widen an existing sample section. It is used in investment requirements modeling to estimate needed capacity improvements. Enter the code which best represents the extent to which it is feasible to widen the existing road. Consider mainly the physical features along the roadway section, such as large single family residences or office buildings, shopping centers and other large enterprises, severe terrain, cemeteries, wet lands, and park land, as well as where widening would be otherwise cost or environmentally prohibitive. <u>Do</u> <u>not</u> <u>consider</u> restrictions because of current right-of-way width, State practices concerning widening, politics, or projected traffic.

The code is to represent the lanes that could be added in both directions; e.g., if a lane could be added for each direction of the roadway, then use code “4”; if one full lane only can be added, use code “3”; if only minor widening or widening narrow lanes can occur, use code “2”. Restriping to narrower lanes, resulting in an additional lane on a multilane facility, does not constitute widening feasibility. When coding this item, also consider medians and other areas already within the right-of-way to be available for widening.

Code	Description
1	No Widening is Feasible
2	Yes, Partial Lane
3	Yes, One Lane
4	Yes, Two Lanes
5	Yes, Three Lanes or More

Items 63-68 — Curves by Class (Numeric; Decimal)
These items provide specific information regarding the length of horizontal curves by degree of curvature for sample sections. They are used in investment requirements modeling to calculate horizontal alignment adequacy and estimate running speed and operating costs. Code for paved rural arterials and urban principal arterials in accordance with Table IV-5. Curves by class may be coded for other functional systems if the data are available; code "0.0" when curve data are not reported. When this item is not reported for the required rural systems, code Horizontal Alignment Adequacy (Item 69).

Table IV-5. Coding Guide for Curves and Grade by Class. (Items 63-69 & 71-77)

Highway Category	Items 63-68	Item 69	Items 71	Item 72-77
	Curves by Class	Horizontal Alignment Adequacy	Vertical Alignment Adequacy	Grades by Class
PAVED - RURAL				
Principal Arterial	Required	Software Coded	Software Coded	Required
Minor Arterial	Required	Software Coded	Software Coded	Required
Major Collector	Not Required	Required	Required	Not Required
PAVED - URBAN				
Principal Arterial	Required	Not Required	Not Required	Required
Minor Arterial	Not Required	Not Required	Not Required	Not Required
Collector	Not Required	Not Required	Not Required	Not Required

Each curve and tangent segment is coded as a separate curve; segments are summed by curve class to obtain the total length in each class. Report the sum of the class lengths for each of the six curve classes in kilometers (miles); the sum of all curve lengths must equal the section length. Code according to the reporting units chosen for Metric (or English) Reporting Units (Item 3); when reporting in Metric units, curve classes are identified by the radius length in meters. They are approximately equivalent to the English unit degree of curvature classes shown below:

Item	Curve Classes			Length of Curves in Class (to 3 decimals) xx.xxx
	Curve Class	Radius Length (Metric)	Degree of Curvature (English)	
63	A	506+	0.0- 3.4	——
64	B	321- 505	3.5-5.4	——
65	C	206- 320	5.5- 8.4	——
66	D	126- 205	8.5-13.9	——
67	E	61- 125	14.0-27.9	——
68	F	<61	28+	——

Item 69 — Horizontal Alignment Adequacy (Rural Data Item)(Software Calculated)
This item provides information about the adequacy of horizontal alignment when curve data are not reported. It is used in investment requirements modeling to estimate horizontal alignment deficiencies and in the truck size and weight analyses. Code for all paved sample sections unless Curves by Class (Items 63 - 68) are coded for the section. (See Table IV-5.) If curves by class are coded, horizontal alignment adequacy will be calculated for paved sections from the curve data. Use the following codes:

Code	Description
0	Curve data are reported or this item is not required for the section.
1	All curves meet appropriate design standards for the type of roadway. Reduction of curvature would be unnecessary even if reconstruction were required to meet other deficiencies (i.e., capacity, vertical alignment, etc.).
2	Although some curves are below appropriate design standards for new construction, all curves can be safely and comfortably negotiated at the prevailing speed limit on the section. The speed limit was not established by the design speed of curves.
3	Infrequent curves with design speeds less than the prevailing speed limit on the section. Infrequent curves may have reduced speed limits for safety purposes.
4	Several curves uncomfortable or unsafe when traveled at the prevailing speed limit on the section, or the speed limit on the section is severely restricted due to the design speed of curves.

Item 70 — Type of Terrain (Rural Data Item)(Numeric; Codes)
This item provides information on the type of terrain through which the sampled roadway passes. It is used in investment requirements modeling to calculate capacity and estimate needed capacity improvements and in the truck size and weight analysis process. For all rural sample sections, enter the code that best characterizes the terrain classification for the sampled roadway. In coding this item, consider the terrain of an extended length of the roadway upon which the sample is located rather than the grade on the specific sample section by itself. The extended roadway section may be several miles long and contain a number of upgrades, downgrades, and level sections; for long sample sections, such as rural freeway samples extending between interchanges, the extended roadway section and the sample section may be the same. Code according to the following table:

Code	Terrain Type
0	Not Applicable; this is an Urban Section.
1	**Level**: Any combination of grades and horizontal or vertical alignment that permits heavy vehicles to maintain the same speed as passenger cars; this generally includes short grades of no more than 2 percent.
2	**Rolling**: Any combination of grades and horizontal or vertical alignment that causes heavy vehicles to reduce their speeds substantially below those of passenger cars but that does not cause heavy vehicles to operate at crawl speeds for any significant length of time.
3	**Mountainous**: Any combination of grades and horizontal or vertical alignment that causes heavy vehicles to operate at crawl speeds for significant distances or at frequent intervals.

Item 71 — Vertical Alignment Adequacy (Rural Data Item)(Software Calculated)

This item provides information about the adequacy of vertical alignment when grade data are not reported. It is used in investment requirements modeling to estimate vertical alignment deficiencies. Code for all paved sample sections unless Grades by Class (Items 72 - 77) are coded for the section. (See Table IV-5.) If grades by class are coded, vertical alignment adequacy will be calculated for all paved sections from the grade data. Use the following codes:

Code	Description
0	Grade data are reported or this item is not required for the section.
1	All grades (rate and length) and vertical curves meet minimum design standards appropriate for the terrain. Reduction in rate or length of grade would be unnecessary even if reconstruction were required to meet other deficiencies (i.e., capacity, horizontal alignment, etc.).
2	Although some grades (rate and/or length) and vertical curves are below appropriate design standards for new construction, all grades and vertical curves provide sufficient sight distance for safe travel and do not substantially affect the speed of trucks.
3	Infrequent grades and vertical curves that impair sight distance or affect the speed of trucks (when truck climbing lanes are not provided).
4	Frequent grades and vertical curves that impair sight distance or severely affect the speed of trucks; truck climbing lanes are not provided.

Items 72-77 — Grades by Class (Numeric; Decimal)

These items provide specific information regarding the length of vertical grades by percent gradient for sample sections. It is used in investment requirements modeling to calculate vertical alignment adequacy and estimate running speed and operating costs and in the truck size and weight analysis process. Code for paved rural arterials and urban principal arterials in accordance with Table IV-5. Grades by class may be coded for other functional systems if the data are available; code “0.0” when grade data are not reported. When this item is not reported for the required rural systems, code Vertical Alignment Adequacy (Item 71).

Each grade and flat segment is coded as a separate segment; segments are typically measured between vertical points of intersection (VPI) and summed by grade class to obtain the total length in each class. Report the sum of the class lengths for each of the six grade classes in kilometers (miles); the sum of all grade lengths must equal the section length. Code according to the reporting units chosen for Metric (or English) Reporting Units (Item 3). Report the following data:

Item	Grade Class	Grade Classes by Gradient (Percent)	Length of Grades in Class (to 3 decimals) xx.xxx
72	A	0.0-0.4	——
73	B	0.5-2.4	——
74	C	2.5-4.4	——
75	D	4.5-6.4	——
76	E	6.5-8.4	——
77	F	8.5+	——

Item 78 — Percent Passing Sight Distance (Rural Data Item)(Numeric; Integer)
This item provides specific information on the percent of the sample section meeting the sight distance requirement for passing. It is used in investment requirements modeling to calculate capacity and estimate running speed and for truck size and weight analysis purposes. Code this numeric item for all rural, paved two-lane sample sections. Enter the percent of the section length that is striped for passing. Where there is a discernable directional difference, code for the more restrictive direction. Code "0" for nonapplicable sections as well as for very curved or very hilly sections without passing zones.

Item 79 — Weighted Design Speed (Software Calculated)
This item is a calculated value that provides a design speed weighted by the length of individual horizontal curves and tangents in a sample section. It is used in investment requirements modeling to calculate capacity and estimate needed capacity improvements. This item is calculated by the HPMS software from curve data; when curve data are not provided, a default value based upon functional system and facility type is used as shown in the following table.

Facility Type	Functional Class								
	1	2	6	7	11	12	14	16	17
Multilane Divided	70	70	70	65	70	70	70	60	55
Multilane Undivided	70	70	70	60	70	70	70	55	45
2/3 Lane	70	70	65	60	70	65	65	55	45

Item 80 — Speed Limit (Numeric; Integer)
This item provides information on the posted speed limit on sample sections. It is used in investment requirements modeling to estimate running speed and for other analysis purposes, including delay estimation. Enter the daytime speed limit for automobiles posted or legally mandated on the greater part of the section. Code according to the reporting units chosen for Metric (or English) Reporting Units (Item 3). If there is no legally mandated maximum daytime speed limit for automobiles, code "999".

Item 81 — Percent Peak Single Unit Trucks (Numeric; Integer)
This item provides information on truck use on a sample section. It is used in investment requirements modeling to calculate capacity and design volumes. Code this item with the percent from Item 82 unless the State has determined that the percent of trucks in the peak period is different from the average daily percent trucks. Some routes, such as urban commuter or recreational routes, may exhibit significant differences in truck percentages between peak period and average daily operation; these differences may have a significant impact on route capacity. In cases where the State determines that differing peak period operations have a significant bearing on route capacity, code a separate peak usage value for the section, even if it is an estimated value.

Item 82 — Percent Average Daily Single Unit Trucks (Numeric; Integer)
This item provides information on truck use on a sample section. It is used in investment requirements modeling to estimate pavement deterioration and operating speeds, in the cost allocation pavement model, and in the truck size and weight analysis process. Code single unit truck traffic as a percentage of section AADT to the nearest whole percent. This value should be representative of all single unit truck activity over all days of the week and seasons of the year as a percent of total annual traffic. Single unit trucks include vehicle classes 4 through 7 (buses through four-or-more axle, single-unit trucks). Further information on vehicle classes is included in Chapter III. Section specific measured values are requested. If not available, use values derived from classification station data on the same route or on a similar route with similar traffic in the same area. Avoid using a single statewide value or statewide values by functional system.

Item 83 — Percent Peak Combination Trucks (Numeric; Integer)
This item provides information on truck use on a sample section. It is used in investment requirements modeling to calculate capacity and design volumes. Code this item with the percent from Item 84 unless the State has determined that the percent of trucks in the peak period is different from the average daily percent trucks. Some routes, such as urban commuter or recreational routes, may exhibit significant differences in truck percentages between peak period and average daily operation; these differences may have a significant impact on route capacity. In cases where the State determines that differing peak period operations have a significant bearing on route capacity, code a separate peak usage value for the section, even if it is an estimated value.

Item 84 — Percent Average Daily Combination Trucks (Numeric; Integer)
This item provides information on truck use on a sample section. It is used in investment requirements modeling to estimate pavement deterioration and operating speeds, in the cost allocation pavement model, and in the truck size and weight analysis process. Code combination truck traffic as a percentage of section AADT to the nearest whole percent. This numeric value should be representative of all combination truck activity over all days of the week and seasons of the year as a percent of total annual traffic. Combination trucks include vehicle classes 8 through 13 (four-or-less axle, single-trailer trucks through seven-or-more axle, multi-trailer trucks). Further information on vehicle classes is included in Chapter III. Section specific measured values are requested. If not available, use values derived from classification station data on the same route or on a similar route with similar traffic in the same area. Avoid using a single statewide value or statewide values by functional system.

Item 85 — K-Factor (Numeric; Integer)
This item provides the design hour volume as a percent of AADT for a sample section. It is used in investment requirements modeling to calculate capacity and estimate needed capacity improvements, in the cost allocation pavement model, and for other analysis purposes, including delay estimation. Code the K-factor for the section to the nearest percent. The K-factor is the design hour volume (30th highest hour) as a percentage of the annual average daily traffic. Section specific values are requested. If not available, use values derived from continuous count station data on the same route or on a similar route with similar traffic in the same area. Avoid using a single statewide value or statewide values by functional system. The K-Factor normally ranges from 6 to 18 percent.

Item 86 — Directional Factor (Numeric; Integer)
This item provides the percent of design hour volume flowing in the peak direction on a sample section. It is used in investment requirements modeling to calculate capacity and estimate needed capacity improvements, in congestion, delay, and other analyses, and in the cost allocation pavement model. Enter the percentage of the design hour volume (30th highest hour) flowing in the peak direction. Code "100" for one-way facilities. Section specific values are requested. If not available, use values derived from

continuous count station data on the same route or on a similar route with similar traffic in the same area. Avoid using a single statewide value or statewide values by functional system. The directional factor normally ranges from 50 to 70 percent.

Item 87 — Number of Peak Lanes (Numeric; Integer)
This data item is used to provide information on the number of lanes used in the peak hour direction of flow on a sample section. It is used in investment requirements modeling to calculate capacity, and in congestion analyses, including estimates of delay. Code the number of through lanes used in the peak period in the peak direction. Include reversible lanes, parking lanes, or shoulders that legally are used for through traffic whether for SOV or HOV operation. For rural 2- or 3-lane sections, code the number of through lanes in both directions in the peak period. The number of peak lanes is used in the HCM-based capacity calculation procedure (see Appendix N).

Items 88-89 — Left/Right Turning Lanes (Urban Data Items)(Numeric; Codes)
These items provide information on the presence of turning lanes at a typical intersection on a sample section. They are used in investment requirements modeling to calculate capacity and in congestion analyses, including estimates of delay. Enter the code from the following tables that best describes the peak-period turning lane operation on the inventory section. Where peak capacity for a section is governed by a particular intersection that is on the section, code the turning lane operation at that location; otherwise code for a typical intersection. Code turning lanes and the percent green time for the same intersection. Include turning lanes that are located at entrances to shopping centers, industrial parks, and other large traffic generating enterprises as well as public cross streets.

Code a continuous turning lane with painted turn bays as a continuous turning lane. Code a through lane that becomes an exclusive turning lane at an intersection as a turning lane (see Figure IV-8); however, if through and turning movements can be made from a lane at an intersection, it is not a turning lane.

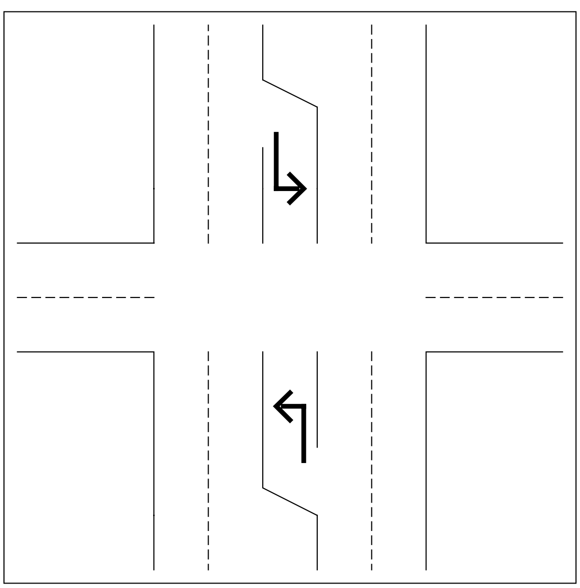


Figure IV-7. Left Turn Lanes

__Examples__:

Figure IV-7 contains a section that has a single left turn lane, and nothing for the right turns; both left and right turns are permitted in the peak period. Code "3" for Item 88 (turns permitted; a single left turning lane exists) and "4" for Item 89 (turns permitted; no right turning lanes exist). There are four through lanes (Item 34) and two peak period through lanes (Item 87).

Figure IV-8 contains what appears to be four through lanes, but one in each direction becomes an exclusive right turn lane at the intersection; both left and right turns are permitted in the peak period. The correct codes would be "4" for Item 88 (turns permitted; no left turning lanes exist) and "3" for Item 89 (a single right turning lane exists). The number of through lanes is 2 (Item 34) and the number of peak period through lanes is 1 (Item 87).

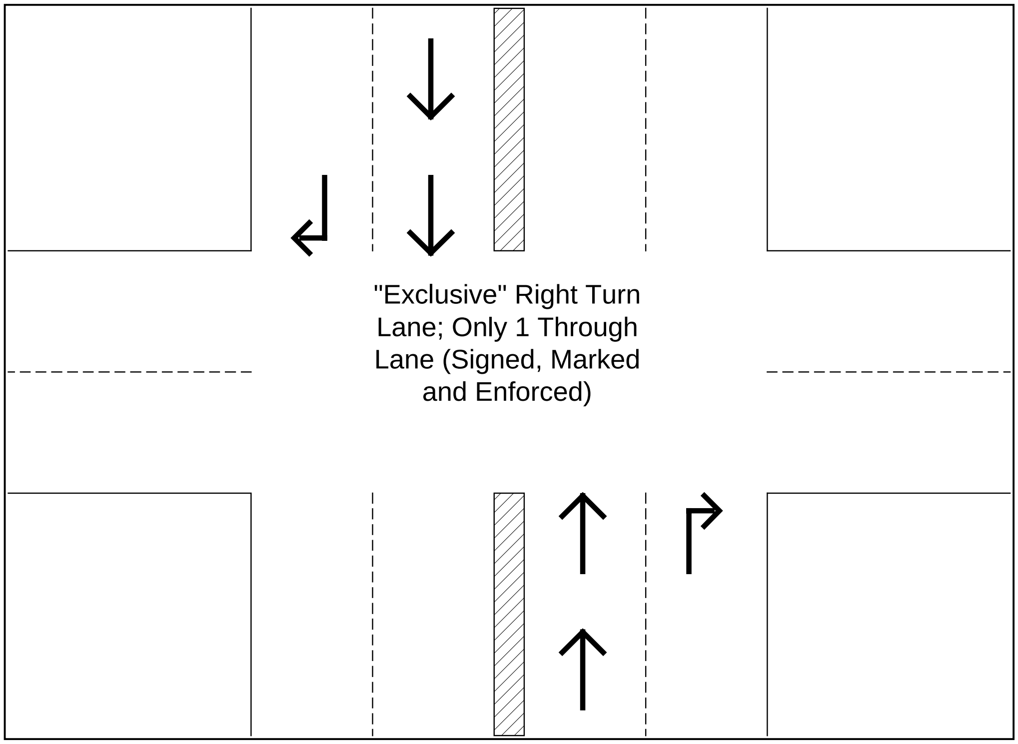


Figure IV-8. Exclusive Right Turn Lane

Item 88 — Left Turn Lane Codes (Numeric; Codes)

Code	Description
0	Not applicable; this is a rural section or **no intersections exist on the section.**
1	Turns permitted; multiple exclusive left turning lanes exist. Through movements are prohibited in these lanes. Multiple turning lanes allow for simultaneous turns from all turning lanes.
2	Turns permitted; a continuous exclusive left turning lane exists from intersection to intersection. Through movements are prohibited in this lane.
3	Turns permitted; a single exclusive left turning lane exists.
4	Turns permitted; no exclusive left turning lanes exist.
5	No left turns are permitted during the peak period.

Item 89 — Right Turn Lane Codes (Numeric; Codes)

Code	Description
0	Not applicable; this is a rural section or **no intersections exist on the section**.
1	Turns permitted; multiple exclusive right turning lanes exist. Through movements are prohibited in these lanes. Multiple turning lanes allow for simultaneous turns from all turning lanes.
2	Turns permitted; a continuous exclusive right turning lane exists from intersection to intersection. Through movements are prohibited in this lane.
3	Turns permitted; a single exclusive right turning lane exists.
4	Turns permitted; no exclusive right turning lanes exist.
5	No right turns are permitted during the peak period.

Item 90 — Prevailing Type of Signalization (Urban Data Item)(Numeric; Codes)
This item describes the predominant type of signal system on a sample section. It is used in the investment requirements modeling process to calculate capacity and estimate delay. Enter the code that best describes the predominant type of signal system for the direction of travel on the inventory section. Signal information may be coded for rural sections on an optional basis.

Code	Description
0	Not applicable; this is a rural section.
1	Uncoordinated Fixed Time (may include pre-programmed changes for peak or other time periods).
2	Traffic Actuated.
3	Progressive (coordinated signals through several intersections).
4	No signal systems exist.

Item 91 — Typical Peak Percent Green Time (Urban Data Item)(Numeric; Integer)
This item provides information on the typical through lane percent green time in effect at intersections on a sample section. It is used in investment requirements modeling to calculate capacity and in congestion analyses, including estimates of delay. Enter the percent green time in effect during the peak period for through traffic at signalized intersections for the direction of travel on the inventory section; percent green time may be coded for rural sections on an optional basis. Where peak capacity for a section is governed by a particular intersection that is on the section, code the percent green time at that location; otherwise code for a typical intersection. Code the percent green time for the same intersection where Items 88 and 89 are coded. Code “0” if no signalized intersections exist or if the section is rural. Use results of a field check of several peak period light cycles to determine a “typical” green time for traffic actuated/demand responsive traffic signals. Ignore separate green-arrow time for turning movements.

Items 92-94 — Number of At-Grade Intersections (Numeric; Integer)
These items provide a count of the number of intersections and traffic controls on the sample section. They are used in investment requirements modeling to calculate capacity and estimate delay. Code the number of intersections on the inventory route according to the following table. Include at-grade intersections at entrances to shopping centers, industrial parks, and other large traffic generating enterprises.

Item	Description
92	**Signals**: Enter the number of at-grade intersections with a signal controlling traffic on the inventory route. A signal that cycles through red, yellow, and green for all or a portion of the day should be counted as a signalized intersection. If none, enter "0."
93	**Stop Signs**: Enter the number of at-grade intersections with a stop sign controlling traffic on the inventory route. A continuously operating, flashing red signal should be counted as a stop sign control. If none, enter "0".
94	**Other or No Controls**: Enter the number of at-grade intersections where traffic on the inventory route is not controlled by either a signal or a stop sign; or is controlled by other types of signing; or has no controls. A continuously operating, flashing yellow signal should be considered as "other or no control." If none, enter "0."

Care needs to be taken to prevent over counting. Special treatment is required when a sample section begins and/or ends with a counted data item. This is accomplished by doing the following:

- Choose a statewide direction for inventory (South to North, West to East, etc.)
- Choose a statewide rule to always count the beginning only or the ending only, but never both
- Count and report accordingly

In the upper portion of Figure IV-9, the intersection count is the same (2) using either the beginning only or ending only rule. In the lower portion of Figure IV-9, a count of two results using the bottom to top inventory direction and the beginning only rule. If the inventory direction remains bottom to top, but the ending only rule is followed, the count is only one.

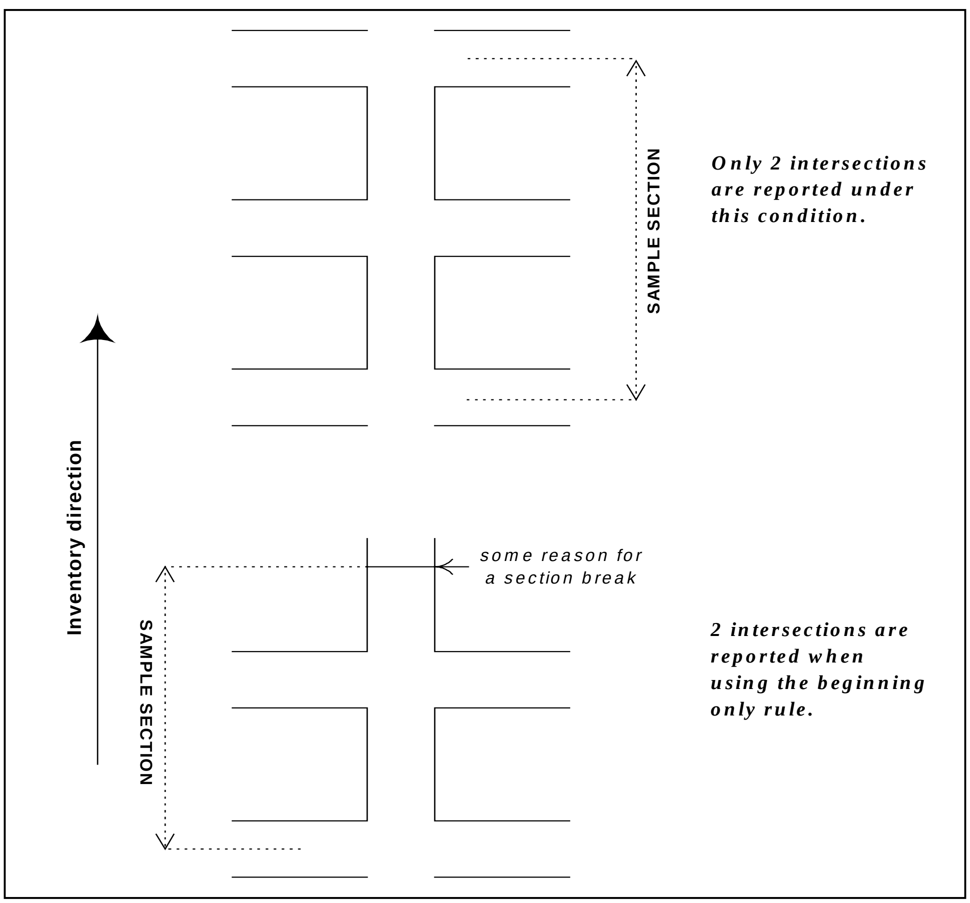


Figure IV-9. Count Items

Item 95 — Peak Capacity (Software Calculated)
This item provides existing peak hour capacity for a sample section. It is used in investment requirements modeling to calculate capacity, in the cost allocation pavement model, and in congestion, delay, and other analyses.

The rural and urban peak capacity values are calculated by procedures in the HPMS software provided to the States. The procedures used in the software for determining highway capacity conform to the Highway Capacity Manual (HCM). The capacity calculations are based on service flow rates for level of service E. Capacity calculation procedures are described in Appendix N.

All urban capacity is for the peak direction as is rural capacity for freeways and other multi-lane facilities. If a rural facility has 2 or 3 lanes with one-way operation, it is considered to be a multi-lane facility for determining capacity. The capacity for rural facilities with 2 or 3 lanes and two-way operation is for both directions.

The state may override the calculated capacity if it determines that the capacity is too low or too high because of operational conditions that are not appropriately reflected in the HPMS data items used in the calculation.

Item 96 — Volume/Service Flow Ratio (V/SF) (Software Calculated)
This item is a computed value reflecting peak hour congestion for a sample section. It is used in investment requirements modeling to estimate needed capacity improvements, in the national highway database, and for congestion, delay, and other data analyses. This value is generated by the HPMS software from HPMS data; procedures are described in Appendix N.

Item 97 — Future AADT (Numeric; Integer)
This item provides forecast AADT information for a sample section. It is used in investment requirements modeling to estimate deficiencies and future improvement needs, in the cost allocation pavement model and in other analytical studies. Code the forecasted two-way AADT for the year coded in Item 98, Year of Future AADT. The intent is to include a 20-year forecast in the HPMS but the estimate may be for some other period of time within an 18 to 25 year time span. This item may be updated at any time but must be updated when the forecast falls below 18 years.

Future AADT should come from a technically supportable State procedure or data from MPOs or other local sources. HPMS forecasts for urbanized areas should be consistent with those developed by the MPO at the functional system and urbanized area level.

For example, the expanded HPMS sample value of travel for the urban OF&E functional system in an urbanized area should be consistent with the MPO travel forecast for that functional system. Total travel from the expanded HPMS sample for all functional systems in an urbanized area should also be consistent with total travel estimates produced by MPO models.

Link-by-link comparisons may not be possible to attain due to differences in the MPO network and the on-the-ground road system covered by the HPMS.

Item 98 — Year of Future AADT (Numeric; Integer)
This item provides the year for which the AADT has been forecast. It is used to normalize the forecast AADT to a consistent 20-year horizon. Enter the four-digit year for which Future AADT (Item 97) has been forecasted. This cannot be for less than 18 years nor more than 25 years from the data year (Item 1).

CHAPTER V

LINEAR REFERENCING SYSTEM REQUIREMENTS

In the past, HPMS data has been analyzed and viewed as tables, charts, and graphs. Furthermore, any analysis of HPMS data could only include data fields contained within the HPMS with little opportunity to use information outside it. With the advent of Geographic Information Systems (GIS), a new spatial dimension is now being introduced into HPMS analysis.

What is GIS? Within the context of this chapter, it is sufficient to say it is a way to view and analyze data spatially using specialized software. What this means is that previously discrete databases can now be related together and examined; a relationship that exists through the spatial coordinates these data share. While there are a variety of methods used to locate objects in the real world, the most commonly used among State Departments of Transportation (DOTs) are Linear Referencing Systems (LRS). This chapter contains the requirements for reporting the State's LRS data. The guidelines presented will allow the State to submit its LRS information in a format that will allow it to be incorporated into the FHWA's GIS.

The GIS will advance HPMS state-of-the-art and will enable FHWA, the States, and others to analyze HPMS data for rural arterials, urban principal arterials, and other NHS roadways within a spatial context. The ability to integrate data through GIS will result in enhanced analysis and presentation of the HPMS data State and Nation wide. Introducing this spatial component facilitates greater versatility of the HPMS in its application and integration with other databases, and enables the HPMS to meet the increasing demands placed on it as a transportation analytical and management tool. The HPMS GIS is an important step to increase the effectiveness of HPMS as an information system. **The LRS information submitted in accordance to Chapter V is in addition to the LRS information reported in Chapter IV.**

The LRS reported in this chapter will be integrated into the National Highway Planning Network (NHPN). The NHPN is the database that contains the geographic or spatial locations of the Nation's principal highways. The NHPN, initially developed in a separate mid-1980's effort sponsored by FHWA, is a digital database representing the National Highway System and the remaining rural arterials and urban principal arterials. The NHPN was developed based on 1:100,000 Digital Line Graphs (DLGs) from the U.S. Geological Survey and augmented by State-supplied information describing roads and streets not represented in the DLGs. In this context, the NHPN represents highway geometry, and the HPMS is its attributes. The two databases are related to each other via LRS information. The LRS, in effect, gives each data base addresses that can be identified in the real world. Through this tie, any location in the NHPN should have a corresponding HPMS record. The two data bases are being brought together through a process called dynamic segmentation, which in many ways resembles a simple database relate. To perform a relate, common fields must exists in all identified databases. In this case, the common fields used to link HPMS to the NHPN are:

- County FIPS
- Inventory Route Number
- Inventory Subroute Number
- Kilometerpoint/Milepoint (KMPT/MPT)

The combination of these data will identify a unique location on the State's highway system. Anything less than this could give ambiguous results.

The county, inventory route, and inventory subroute fields are used to identify a particular portion of a route. The beginning and ending KMPT/MPT fields are used to find a specific location along a route.

The general model for an LRS is that one end of the route is identified as its point of origin. It then accumulates measured distance along its course, in KMPTs/MPTs, until it reaches the end of the route. Typically, States modify this concept to meet their own particular needs. Regardless of how the State accomplishes this, all methods of identifying roadway features can be related back to the general model described above. The instructions in this chapter were written to accommodate the State's existing LRS in order to ensure long-range State support of the LRS and a continuing tie between HPMS and State databases.

Because of the detail involved, all figures in this chapter contain English units. Metric units may be substituted.

The NHPN with LRS attached (either in its entirety or by State or portion thereof) is available to the States and others for use in their GIS activities. The NHPN serves as a national framework for information exchange and will be provided to the U.S. Geological Survey, the Bureau of Census, the Intelligent Transportation System (ITS) community, and the Bureau of Transportation Statistics (BTS) to represent the higher order highways.

GENERAL LRS RULES

One of the biggest challenges faced by the FHWA is converting the 52 different State LRSs into one consistent national LRS. In order to accomplish this efficiently, some rules of standardization must be followed. These rules focus on fundamental components of the LRS by addressing three general areas.

- Defining inventory routes.
- The placement of nodes. Some SHAs do not use nodes in their LRS; however, the FHWA requires the use of nodes for the purpose of LRS accuracy. These nodes do not require the State to change its own internal LRS but have been defined to allow them to be easily added without affecting the former.
- Incorporating LRS discontinuities.

The LRS used is a conventional KMPT/MPT. The KMPT/MPT represents the distance in kilometers/miles along the route from a reference point. The reference point can be a State boundary, county boundary, or the beginning point of a route. This distance may be modified by physical route breaks and KMPT/MPT equations that compensate for gaps or excess KMPT/MPT brought on by realignments or recalibration. The following general rules apply:

Base Network:

All NHS plus remaining rural and urban principal arterial and rural minor arterial routes must have an inventory route number. Existing State inventory routes should be used to maximize the relationship between the State's own road inventory and HPMS databases. These routes can consist of both existing and planned unbuilt facilities (see Item 20 in Chapter IV).

General LRS Definition:

- An LRS will be defined for each of the inventory routes identified above.
- Only one LRS is to be reported for each inventory route. Independently aligned roadways (divided highways) are treated as one highway with one KMPT/MPT system.
- Two or more inventory routes may not be assigned to a given highway link (a stretch of roadway between any two corresponding nodes—see Node Location Criteria below). For

HPMS reporting purposes, one inventory route must be chosen to represent the link and the remaining inventory route(s) must be ended and restarted where it diverges from the chosen inventory route.
- Ramps and collectors/distributors are considered to be part of the mainline system and do not have separate LRSs. Frontage roads belong to functional systems of their own and are to be treated as separate roadways.

Node Location Criteria:

A single node must be established at the following points:

- Beginning of an inventory route
- Where the inventory route crosses another inventory route(s)
- Where the inventory route crosses a county line
- Where the inventory route encounters an equation
- Where the inventory route is temporarily suspended or incurs other types of physical breaks
- Where the inventory route ends

Defining Unique Locations:

A unique location within a State for the HPMS LRS is defined by the combination of county, inventory route, inventory subroute, and KMPT/MPT.

Under certain conditions, duplicate KMPTs/MPTs can occur along a route in a state's linear referencing system. These conditions can occur when the route encounters certain types of equations, route breaks, or county lines. Duplicate KMPTs/MPTs are not allowed on a given inventory route within a county. Inventory subroutes must be used to independently identify highway links with duplicate KMPTs/MPTs.

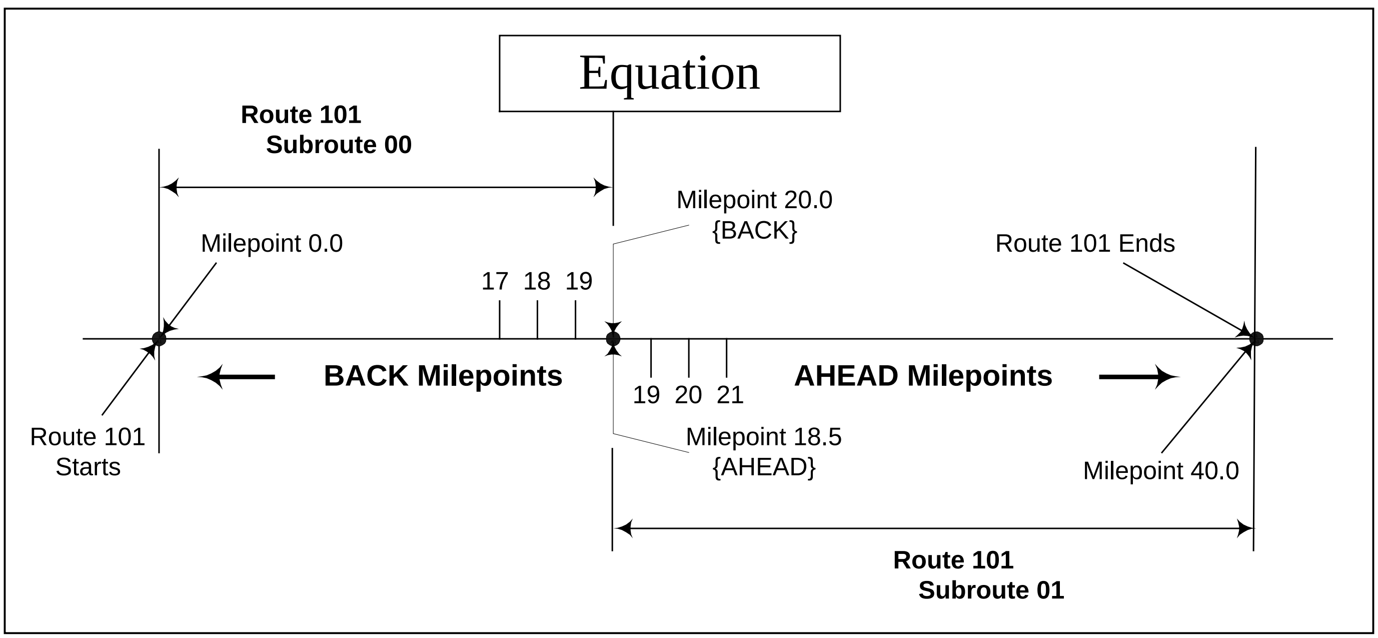
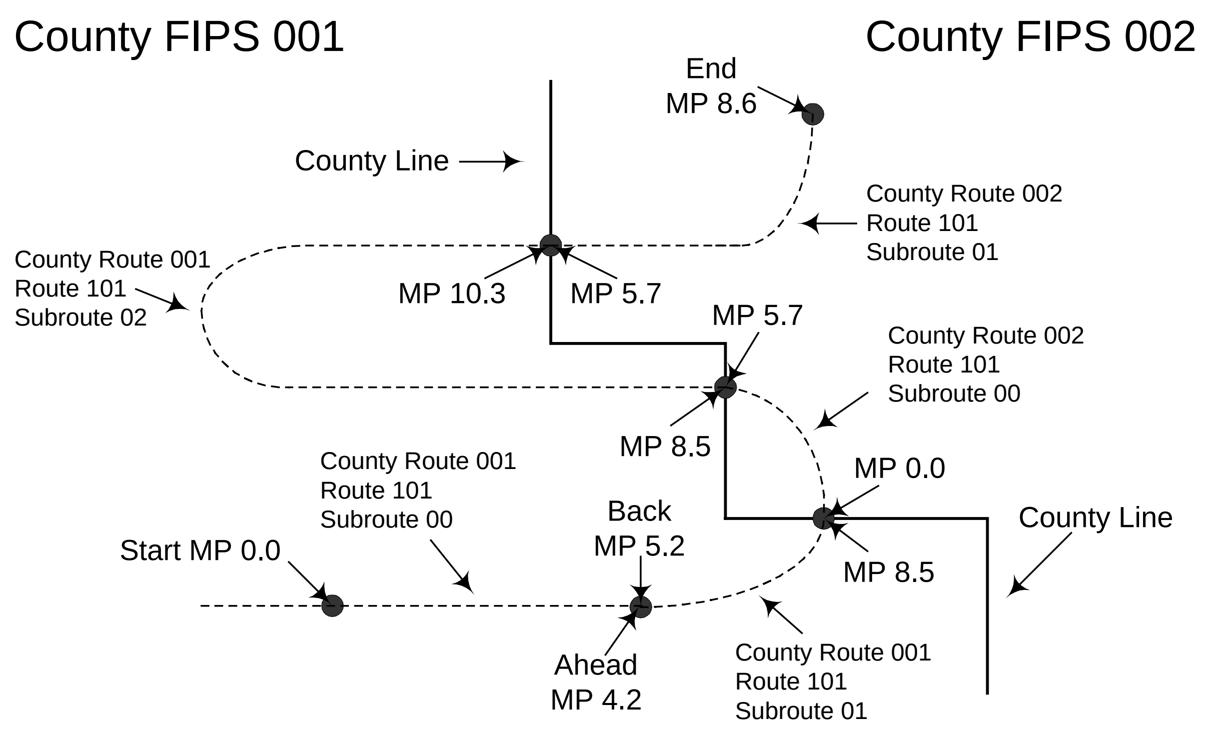


Figure V-1. Duplicate Milepoint Equation

Equations: Locations on a route where discontinuities in KMPTs/MPTs occur (usually caused by construction) are remedied in some State systems through the establishment of an equation. Some equations will create two lengths of roadway with duplicate ranges of KMPTs/MPTs; i.e., the BACK

KMPT/MPT is larger than the AHEAD KMPT/MPT. In such instances, a subroute number must be used to distinguish between duplicate KMPTs/MPTs.

For example, on inventory Route 101, an equation of BACK 20.00 = AHEAD 18.50 creates two 1.50 mile lengths of road with the range of milepoints from 18.50 to 20.00. The route starts at 0.00 milepoint and goes to BACK 20.00 where the mileage is adjusted to AHEAD 18.50, and goes to the end at milepoint 40.00. This route needs to be divided into two subroutes to distinguish between the duplicate milepoints. Subroute number 00 starts at 0.00 milepoint and goes to BACK 20.00. Subroute number 01 starts at AHEAD 18.50 milepoint and goes forward to milepoint 40.00 as illustrated in Figure V-1. The subroute number is continued until either another occurrence of duplicate KMPTs/MPTs (another equation, a route break, or a county boundary) is encountered or the end of the route is reached. For example, if another equation (like the one mentioned above) is encountered, then the subroute number is incremented to 02, etc.



In this example duplicate milepoints/kilometerpoints are created by an equation and a county boundary.

Figure V-2. Re-Entering a County; Equation Created

County Reentries and Route Breaks: When a route reenters a county or a route break occurs (and the intervening mileage is not counted) and duplicate KMPTs/MPTs occur, inventory subroutes must be used to properly identify highway links. For example, in Figure V-2, inventory Route 101 reenters counties 001 and 002 with the entry KMPTs/MPTs equal to the exit milepoints, requiring the subroute numbers to be incremented to maintain uniqueness within the counties.

In Figure V-3, the length of discontinuity in inventory Route 101 is ignored, and the inventory subroute must be incremented to recognize the duplicate KMPTs/MPTs.

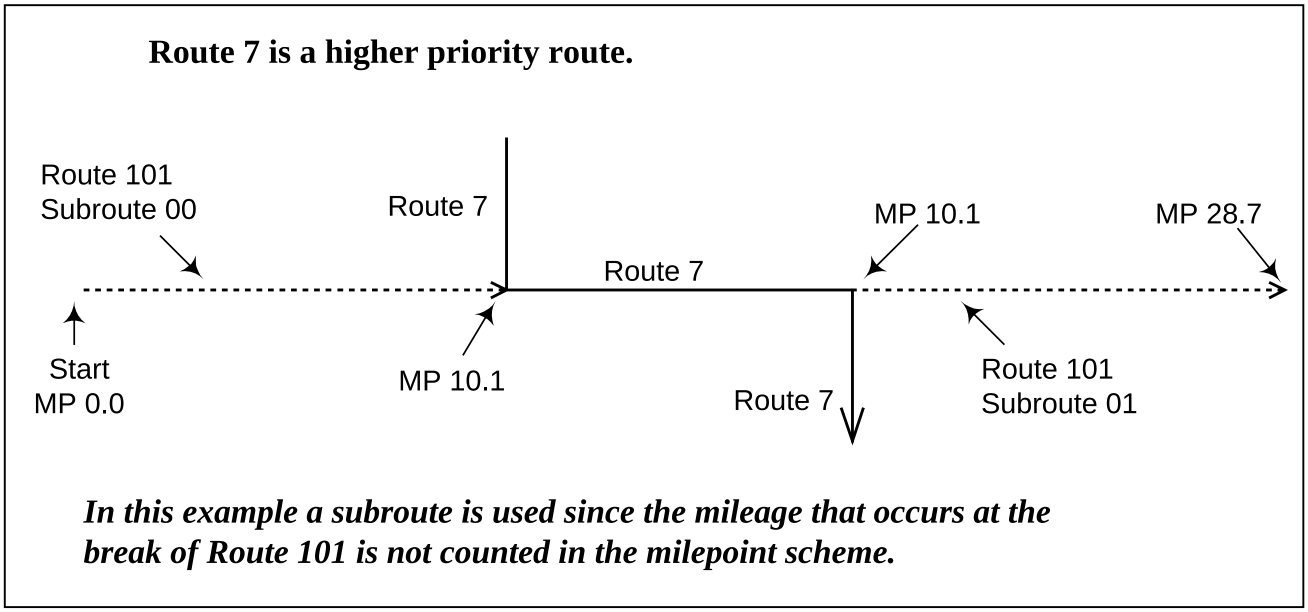


Figure V-3. Route Stops and Restarts at a Different Location; Milepoint Stays the Same

Subroutes:

- An inventory route's subroute numbers must not be duplicated within any one county.
- Inventory subroutes along a route do not have to be in order.
- Inventory subroutes need not be used in cases where gaps in kilometers/milepoints occur on an inventory route. In many cases, duplicate KMPTs/MPTs do not exist on inventory routes. In these instances, KMPTs/MPTs are either continuous or gaps occur where KMPTs/MPTs are skipped. These situations do not require the use of inventory subroutes to uniquely identify links (i.e., the subroute is "00" or remains at the last established value).

Equations that are used to compensate for a gap in the KMPT/MPT system are those in which the BACK KMPT/MPT is smaller than the AHEAD KMPT/MPT. For example, an equation of BACK 12.15 = AHEAD 15.55 creates a 3.40-mile gap in the milepoint system (Figure V-4).

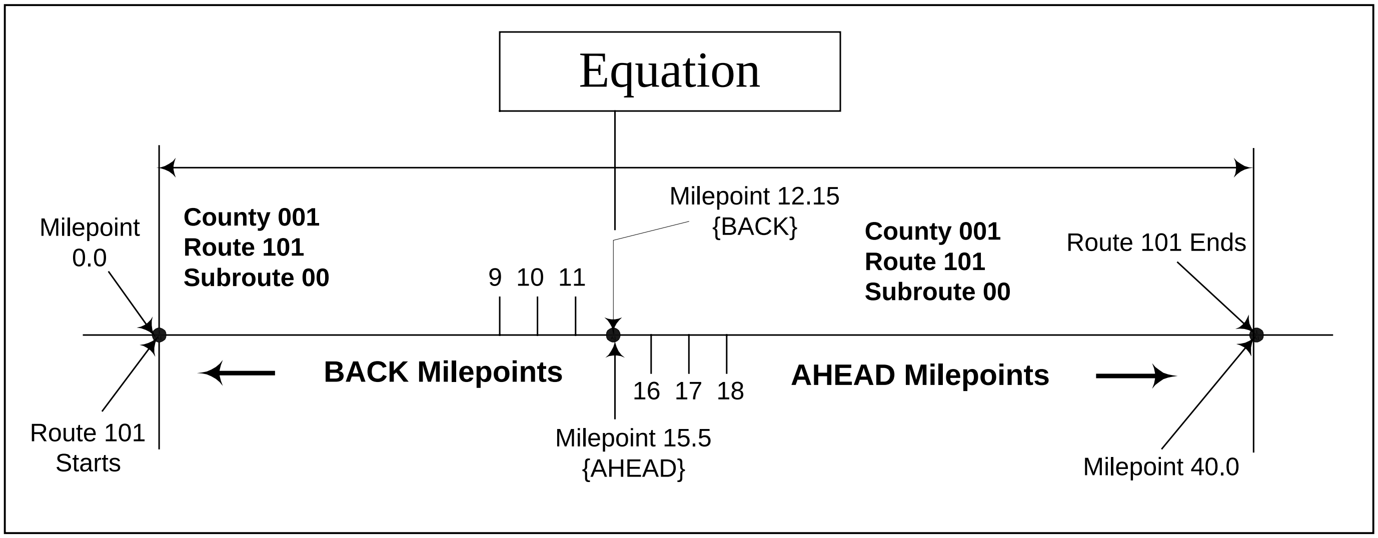


Figure V-4. Nonduplicate Milepoint Equation

Likewise, an inventory route can be stopped and restarted at another location without duplicating KMPTs /MPTs (Figures V-5 and V-6). In the above instances, duplicate KMPTs/ MPTs are not created since the intervening mileage is kept. No changes in inventory subroutes are required.

If no duplicate KMPT/ MPT condition exists within the county, the combination of county, inventory route, and KMPT/MPT will identify a unique location.

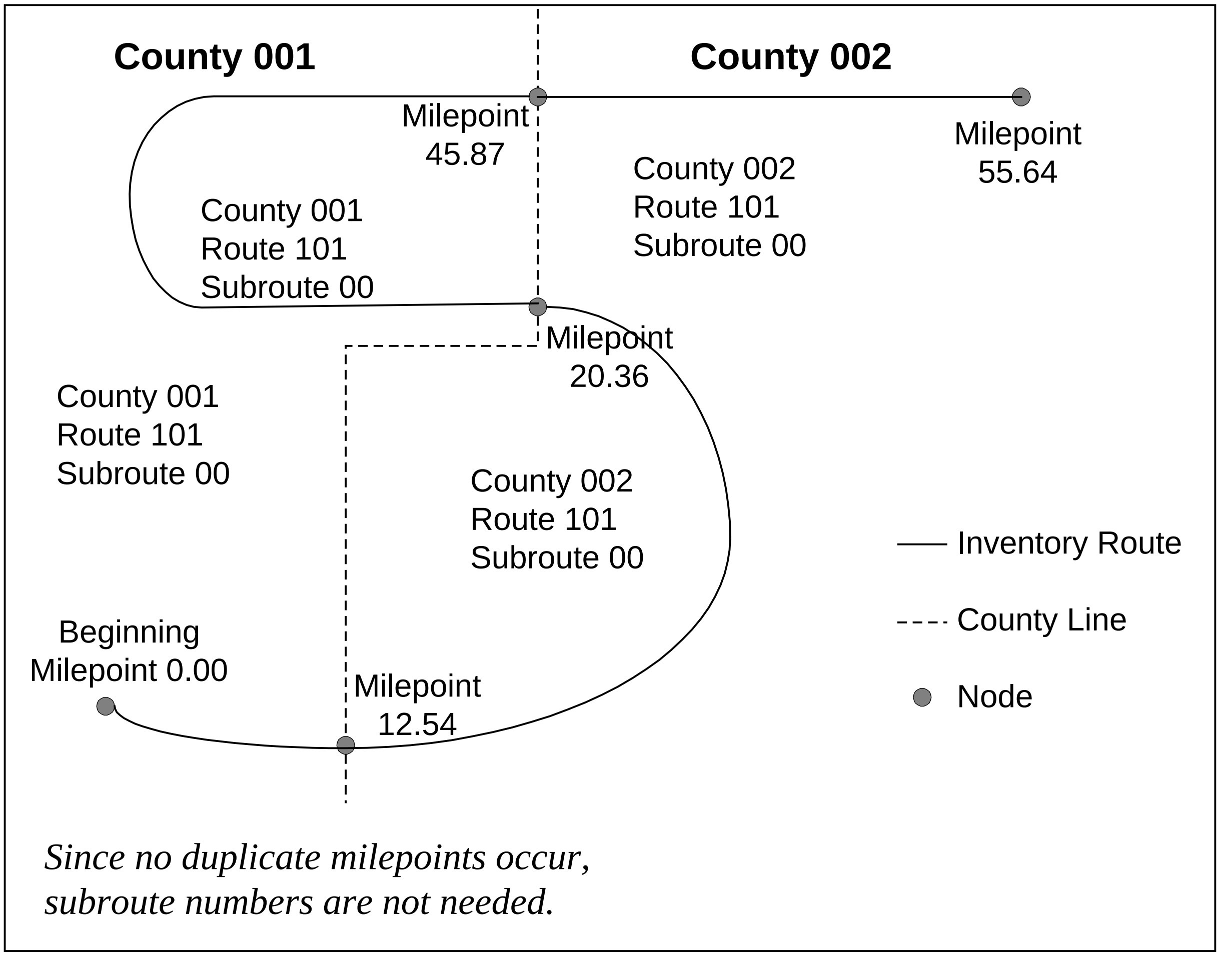
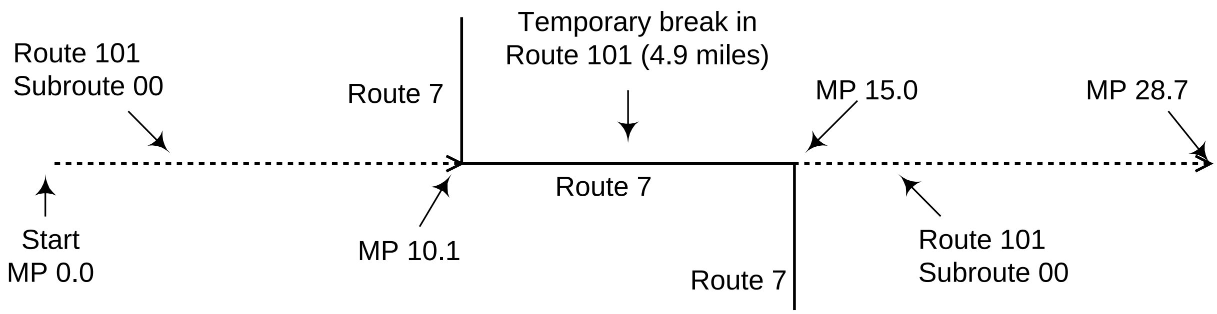


Figure V-5. Re-Entering a County; No Duplicate Milepoints

Route 7 is a higher priority route.



In this example a subroute is not used because the mileage that occurs at the break of Route 101 is counted in the milepoint scheme.

Figure V-6. Route that Stops and Restarts at Different Locations; Milepoint Increases

Effects of LRS on HPMS Sections:

HPMS sections must be adjusted (or divided) where inventory routes or subroutes change along the length of that section. The division of inventory routes into inventory subroutes, where duplicate KMPTs/MPTs occur, could have a direct impact on the physical length of HPMS universe and sample sections. The subroute field effectively creates a new route any time the subroute number changes.

Figure V-7 shows an HPMS section starting at milepoint 8.0 and extending to milepoint BACK 19.6 - not AHEAD 19.6. In this case, no change to the HPMS section is necessary since the section occurs entirely within county 001, Route 101, Subroute 00. Figure V-8 illustrates the same route conditions with the exception that the HPMS section starts at milepoint 8.0 and extends to milepoint AHEAD 19.6 - not BACK 19.6. In this case, the HPMS section must be adjusted (or divided) at that equation point to accommodate the duplicate KMPTs/MPTs. Two sections must be created: milepoint 8.0 to the equation and then from the equation to milepoint AHEAD 19.6.

In contrast, where an HPMS section crosses a nonduplicating equation point, the section need not be adjusted (see Figure V-9).

Because of inventory route design, an HPMS section may have more than one inventory route traversing it. Where this occurs, the HPMS section must be divided to reflect the beginning and ending of the inventory routes. Figure V-10 shows an HPMS section extending across two inventory routes: 101 and 7. In this case, the HPMS section must be divided into three sections at the points where the inventory route changes. Since HPMS sections should already begin/end at county lines, no modification to the sections is required where subroutes are created at county lines.

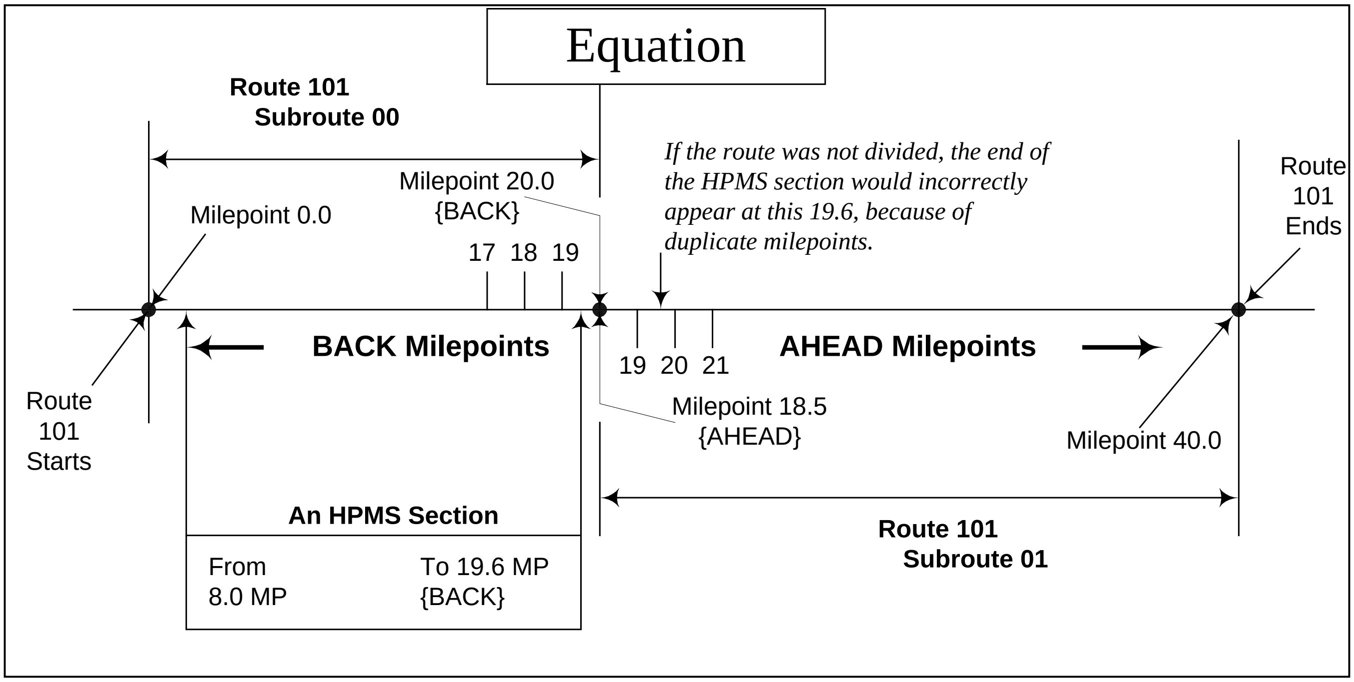


Figure V-7. HPMS Section Near a Duplicate Milepoint Equation

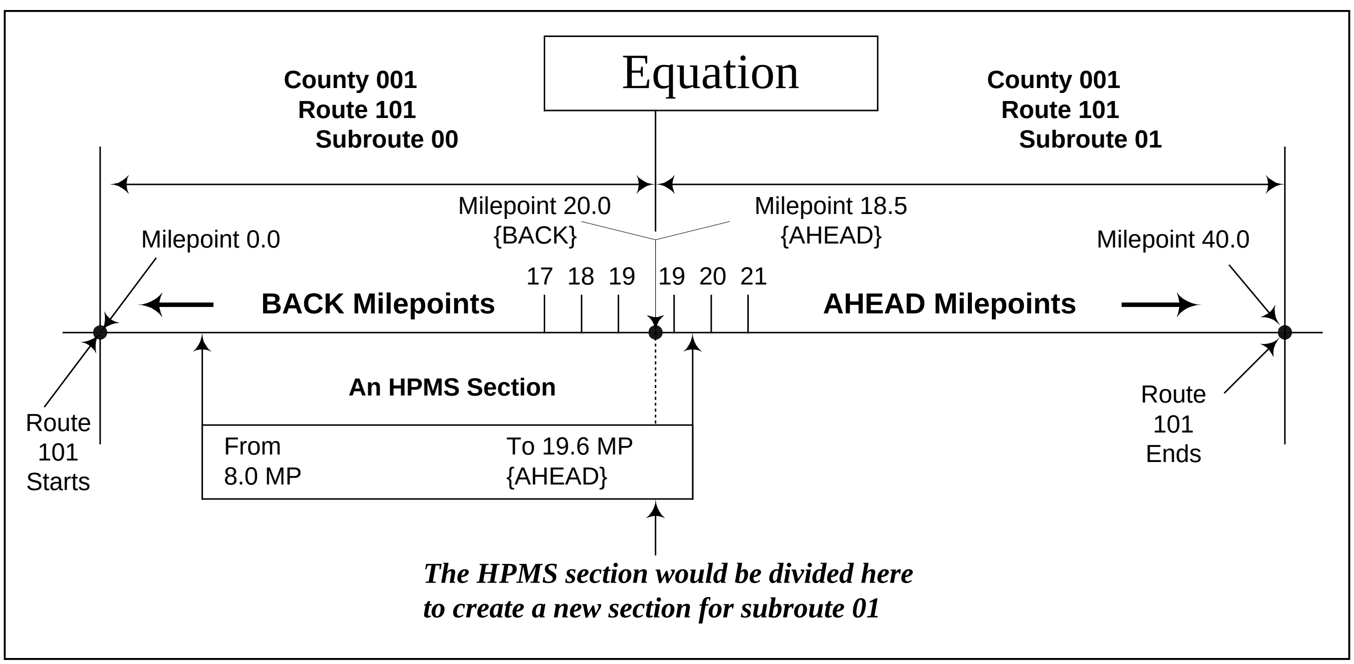


Figure V-8. HPMS Section Crossing a Duplicate Milepoint Equation

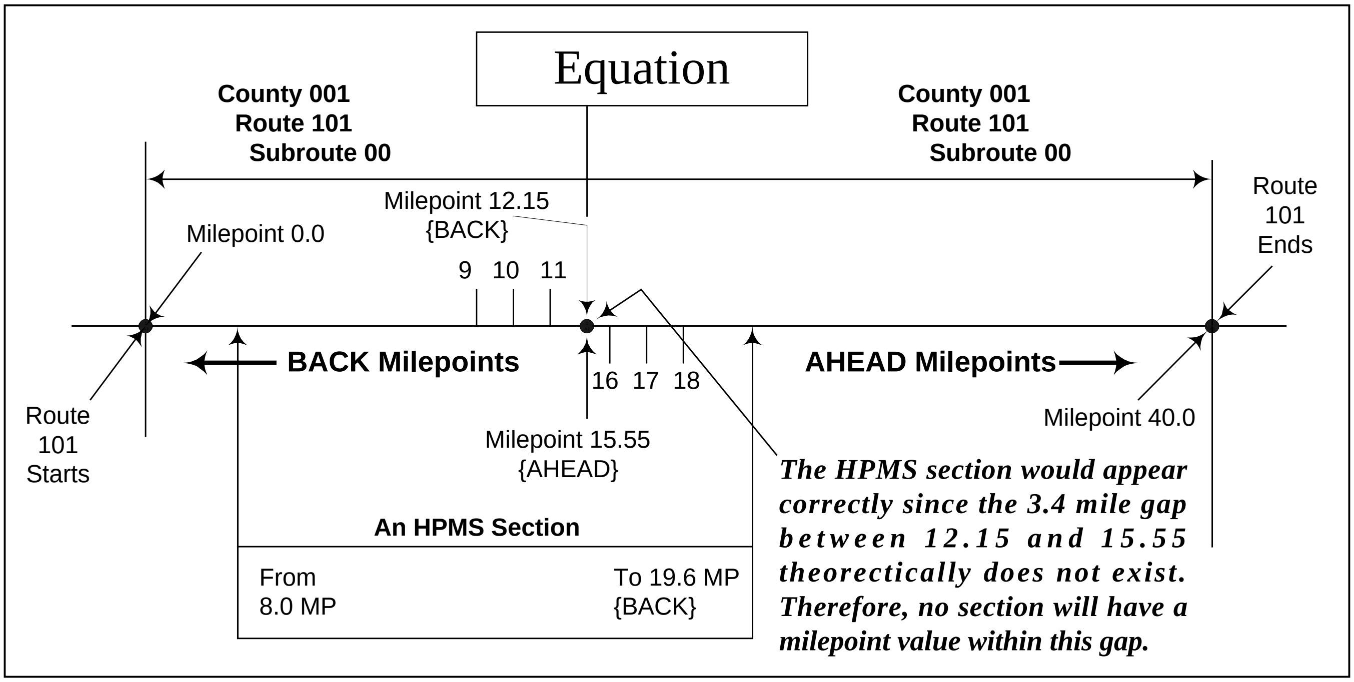


Figure V-9. HPMS Section Crossing a Nonduplicate Milepoint Equation

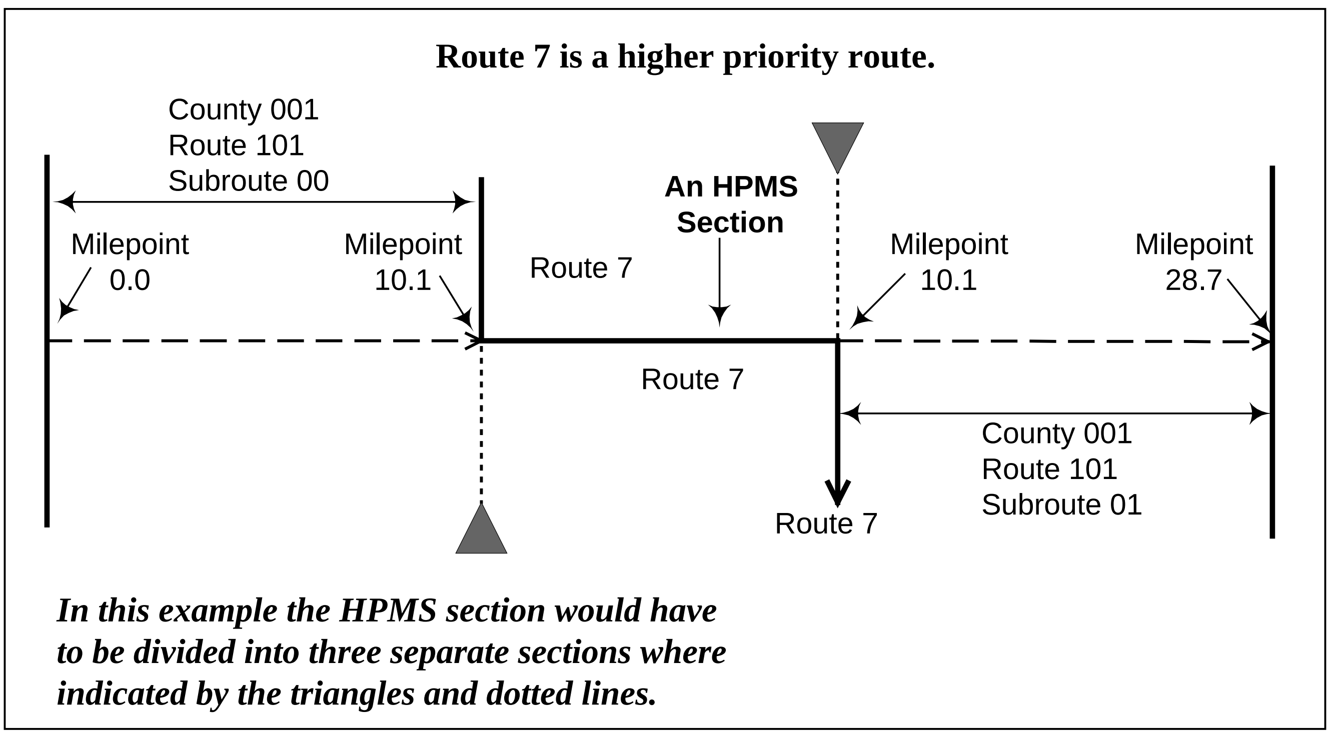


Figure V-10. An HPMS Section that Runs through Overlapping Routes

SUMMARY OF LRS DATA REQUIREMENTS

In addition to the data provided in each HPMS record as outlined in Chapter IV (see Items 9, 10, 11, and 12), each State is to provide the following information. (NOTE: The following discussion assumes that an initial LRS submittal has been made. Appendix H discusses establishing an LRS for the first time.)

LRS SUBMITTAL OPTION 1 - MAPS AND COMPUTER FILES

- ***Inventory Route and Node Maps*** showing the location of **new, deleted and revised** inventory routes, inventory subroutes and nodes on the base network of rural arterials, urban principal arterials and other designated NHS routes. Sufficient coverage of existing, unchanged links and nodes must be provided to enable FHWA to locate changed nodes and links.
- A ***Node Data File*** that, at a minimum, describes **new, revised and deleted** nodes in the network.
- An ***Inventory Route Link Data File*** that, at a minimum, describes **new, revised and deleted** inventory routes within the network.
- **The complete node and link files may be provided if it is more convenient to the States.**

Each product is described in more detail below. A dBase template has been provided to the States for entering and reporting the Node Data and Inventory Route Link Data files discussed above. Data can be submitted on floppy disk, CD, or as an electronic file in dBase or ASCII format.

Inventory Route and Node Map Labeling Instructions

As part of the HPMS submission requirements, States will be required to prepare and submit maps showing, at least new, revised and deleted inventory routes and nodes. **To insure that the revised data is located properly, adjacent node and link information should also be provided.** These maps will be used to ensure the correct location of these inventory routes and nodes on the network in preparation for attaching a linear referencing system and linking HPMS data to the network. The amount of data on these maps should be kept to a minimum and only data necessary to check and transfer the information to the network is requested. Therefore, five basic categories of data must be displayed on the maps:

1. Appropriate portions of the base State highway network — rural arterials, urban principal arterials, and other NHS routes.
2. State/county boundaries.
3. Principal signed routes (U.S., State, etc.).
4. Inventory route and subroute numbers.
5. Nodes with node numbers.

These data should be placed on maps that are at a scale that keeps the number of map sections to a minimum, while maintaining good visual quality for data location and readability.

In order to reduce confusion regarding which number goes with what feature, qualifiers must be added as follows:

Map Feature	Map Qualifiers
Inventory Route	X
Inventory Subroute	( )
Node	N
Signed Routes	No Special Map Qualifiers (Use Existing Prefixes)

For example, inventory Route "234" with a subroute number of 05 would appear on the map as "X234(05)." The "X" and "N" prefixes and "( )" are meant to be used only on the map, so the numbers can be more easily distinguished. **These qualifiers shall not be used on the HPMS records, route/link file, or node file**. To identify the signed route, the State should place the sign route numbers on the map with a prefix (such as "US," "SR," etc.), unless shields exist on the maps that contain the route numbers.

Map Item Description

The Base Network: Contains Interstate, other freeways and expressways, other principal arterials, and rural minor arterials. In addition, those routes not so classified, but are part of the NHS, must also be identified. Finally, officially approved proposed routes are to be included in this base network in keeping with HPMS data Item 20, Planned Unbuilt Facility. Since these LRS data will be used with the HPMS, centerline of dual alignments must be indicated. However, in the case of one-way pairs (couplets), each directional roadway is to be separately defined, as is done in the HPMS records.

Boundaries & County Name Labels: The State must place the name and the county FIPS code within the boundaries.

Principal Signed Route Number Labels: The principal signed route or street name must be provided for each link (i.e., between any two nodes). While the Inventory Route Link Data File allows for up to three signed routes, because of the need for good map readability, only one (the principal route) is required for each link on the map.

Inventory Route and Subroute Number Labels: Only one inventory route and subroute number is to be assigned for each link between any two nodes. In the case of one-way pairs (couplets), each directional roadway is considered a different inventory route. For identification purposes on the map only, route numbers are to begin with an "X" and subroutes are to be enclosed in parentheses.

Nodes and Node Number Labels: Nodes will be established for:

1. Intersections of other inventory routes.
2. Intersections of inventory routes and State boundaries.
3. Intersections of inventory routes and county boundaries.
4. Equation locations.
5. Route termini (including route discontinuity termini).

Each node should have a unique node number clearly displayed beside the node; node numbers must be unique within the State. For identification purposes on the map only, these node numbers are to begin with "N."

All new, revised and deleted nodes and links in the node and link data files must be shown on the map along with adjacent nodes and links.

NODE DATA FILE CODING INSTRUCTIONS

The Node Data File, together with the Inventory Route Link Data File and maps, are used to define the geographic location of the inventory routes and the kilometers/milepoints. These records complement the data supplied in the Inventory Route Link Data File and the Inventory Route and Node Map. In the following table, Items 6-11 identify each of the conditions that will create a node. (Items 1-5 and 12-14 provide other descriptor information about the nodes.) This information is necessary for accurate placement of the node on the network.

Item Number	Position	Length	Data Type	Data Item Description
IDENTIFICATION				
1	1-4	4	N	Year
2	5-6	2	N	State FIPS Code
3a	7-9	3	N	County FIPS Code No. 1
3b	10-12	3	N	County FIPS Code No. 2
4	13	1	N	Record Status
5	14-23	10	AN	Node Number
NODE TYPES				
6	24	1	N	Inventory Route Intersection
7	25	1	N	County Boundary
8	26	1	N	State Boundary
9	27	1	N	Equation
10	28	1	N	Spur Route Termini
11	29	1	N	Inventory Route Termini
COORDINATES (Optional)				
12	30-39	10	N	X Coordinate - Geographic
13	40-49	10	N	Y Coordinate - Geographic
OTHER DESCRIPTORS (Optional)				
14	50-149	100	AN	Description of Node
N = Numeric	AN = Alphanumeric			

All numeric data items must be right justified and zero-filled. The alphanumeric field of Item 5 will be right justified and can use numbers and capitalized English letters. However, this field should not be considered case sensitive. No embedded blanks are allowed. Item 14 may contain any characters, placed anywhere within the 100 positions.

DATA ITEM DETAILS

Identification

Item 1 – Year (Length = 4)
See Item 1 of the HPMS Universe Data Coding Instructions in Chapter IV.

Item 2 – State FIPS Code (Length = 2)
See Item 2 of the HPMS Universe data coding instructions in Chapter IV.

Item 3a – County FIPS Code No. 1 (Length = 3)
A node is created when an inventory route and a county boundary intersect.

When nodes occur at boundaries between adjoining counties, Item 3a will identify one of the two counties sharing the boundary at the node and Item 3b will identify the other county (Figure V-11, Examples A and B). The counties can be identified in any sequence. If the node occurs at a boundary of three or more counties, any two of the possible three will be reported.

When nodes occur within counties or at a State boundary where the county is not joining another county within that State, only one county is identified and will appear in both Items 3a and 3b (See Figure V-11, Examples C and D).

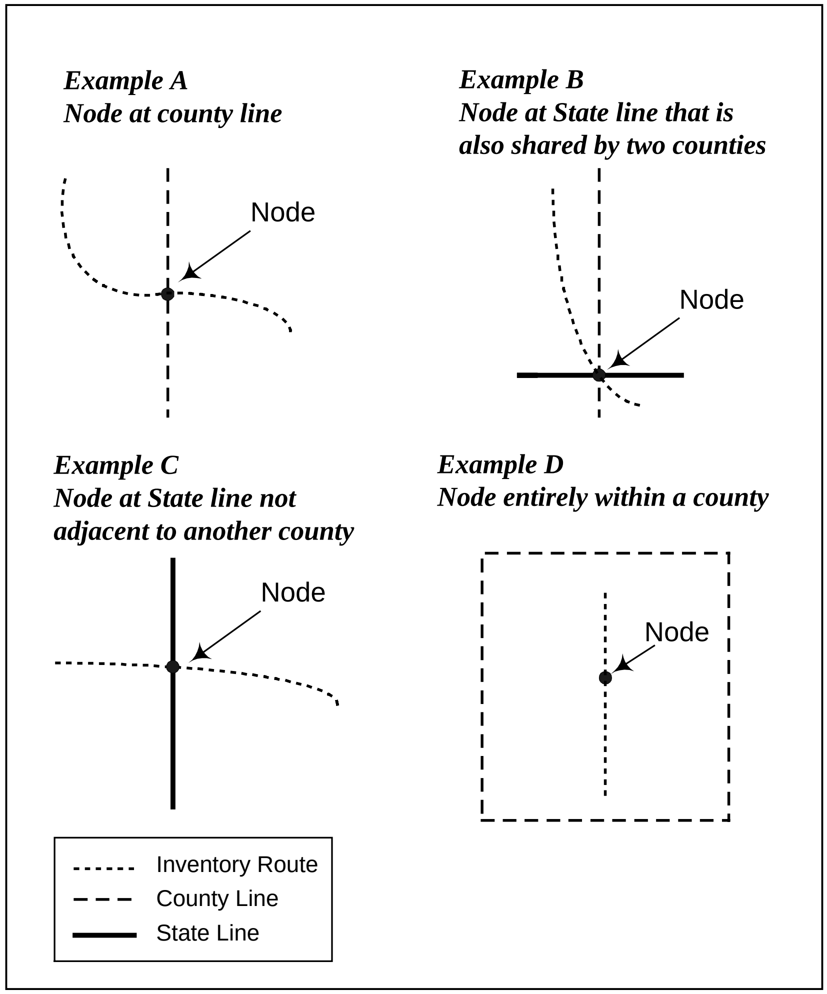


Figure V-11. Nodes and Political Boundaries

Use the three-digit FIPS county code. (See Item 4 of the HPMS Universe Data Coding Instructions in Chapter IV.)

Adjoining counties of neighboring States, under any of the above-described conditions, are not to be coded.

Item 3b – County FIPS Code No. 2 (Length = 3)
This item identifies the second of the two counties sharing the boundary at the node, as discussed above.

Item 4 – Record Status (Length = 1)
This item depicts the condition of the node relative to the data submittal of the past year; that is, a newly created node or an existing node which has incurred a change in one or more of the data items represented in the Node File. In the first year's submittal, all nodes should be coded "0." In subsequent years, if a node is added or one or more of the characteristics have changed, it will be coded as either "2" or "1," respectively. If no change occurs to an existing node, then it will be coded "0." When a node is reported

as being deleted, it must be dropped from subsequent years' submittals. **For example, where a realignment occurs along a route and the old alignment no longer qualifies as part of the "Base Network," the old node(s) will be deleted and new node(s) will be added as needed.**

Code	Description
0	No Change
1	Changed - one or more data items on the node list have been changed or added
2	New Node
3	Deleted Node

Item 5 – Node Number (Length = 10)
All nodes must be identified with a number that can be comprised of both alpha characters and numbers. Each node number must be unique within the State and right justified in the field.

Node Types: Items 6-11 represent different characteristics of a node. Nodes should be created based on one or more of these conditions. Mark each condition that applies to each node (all conditions that describe a particular node should be coded as **"1"**).

Item 6 – Inventory Route Intersection (Length = 1)
Node that occurs where two inventory routes intersect:

Code	Description
0	NO
1	YES

Item 7 – County Boundary (Length = 1)
Node that occurs where an inventory route is intersected by a county boundary:

Code	Description
0	NO
1	YES

Item 8 – State Boundary (Length = 1)
Node that occurs where an inventory route is intersected by a State boundary:

Code	Description
0	NO
1	YES

Note: Since a State line will also be a county boundary, Items 7 and 8 will both be coded as "1" at all State lines.

Item 9 – Equation (Length = 1)
Node that occurs where an equation occurs on an inventory route:

Code	Description
0	NO
1	YES

Item 10 – Spur Route Termini (Length = 1)
Node that occurs where an inventory route terminates without intersecting another inventory route:

Code	Description
0	NO
1	YES

Note: If this item is marked "yes," Item 11 is also to be marked "yes."

Item 11 – Inventory Route Termini (Length = 1)
Node that occurs where an inventory route begins, ends, stops at a discontinuity, or starts after a discontinuity.

Code	Description
0	NO
1	YES

Coordinates (Optional): Specify in the letter of transmittal whether these data exist, and the coordinate system and decimal positions (if any) used for the LRS submittal.

Item 12 – X Coordinate (Length = 10) (Optional)
Enter the "X" coordinate for the node. This should be a nonprojection geographic coordinate, preferably decimal degrees.

Item 13 – Y Coordinate (Length = 10) (Optional)
Enter the "Y" coordinate for the node. This should be a nonprojection geographic coordinate, preferably decimal degrees.

Other Descriptors (Optional)

Item 14 – Description of Node (Length = 100) (Optional)
This item is provided if the State desires to provide additional descriptive information regarding node location. Any alphanumeric characters may be entered, including blanks.

INVENTORY ROUTE LINK DATA FILE CODING INSTRUCTIONS

The Inventory Route Link Data File, together with the Node Data File and maps, are used to define the geographic location of the inventory route and the KMPTs/MPTs. This record compliments the data supplied in the Node Data File and the Inventory Route and Node Map. A link is the roadway between two nodes. The Inventory Route and Node Map illustrates the locations of the links and nodes. All data in this file must be right justified and zero filled.

Item Number	Position	Length	Data Type	Data Item Description
Identification				
1	1-4	4	N	Year
2	5-6	2	N	State FIPS Code
3	7-9	3	N	County FIPS Code
4	10	1	N	Record Status
5	11-20	10	AN	Inventory Route Number
6	21-22	2	N	Inventory Subroute Number
7	23-32	10	AN	Beginning Node Number
8	33-40	8	N	Beginning Milepoint/Kilometerpoint
9	41-50	10	AN	Ending Node Number
10	51-58	8	N	Ending Milepoint/Kilometerpoint
Signed Route 1				
11	59	1	N	Route Signing 1
12	60	1	N	Route Qualifiers 1
13	61-68	8	AN	Route Number 1
Signed Route 2				
14	69	1	N	Route Signing 2
15	70	1	N	Route Qualifiers 2
16	71-78	8	AN	Route Number 2
Signed Route 3				
17	79	1	N	Route Signing 3
18	80	1	N	Route Qualifiers 3
19	81-88	8	AN	Route Number 3
Other				
20	89-118	30	AN	Street Name
N = Numeric		AN = Alphanumeric		

All data must be right justified and zero-filled. Beginning and ending node numbers must be right justified.

DATA ITEM DETAILS

Identification

Item 1 – Year (Length = 4)
See Item 1 of the HPMS Universe Data Coding Instructions in Chapter IV.

Item 2 – State FIPS Code (Length = 2)
See Item 2 of the HPMS Universe Data Coding Instructions in Chapter IV.

Item 3 – County FIPS Code (Length = 3)
See Item 4 of the HPMS Universe Data Coding Instructions in Chapter IV.

Item 4 – Record Status (Length = 1)
This item depicts the status of the route link, relative to the previous year's submittal; that is, a newly created link or an existing link which has incurred a change or addition to one or more of the data items represented in the link file. In the first year's submittal, all links must be coded "0." In subsequent years, if a link is added or one or more of its characteristics have changed, it will be coded as either "2" or "1," respectively. However, if no change occurs to an existing link, then it will be coded "0." When a link is reported as being deleted, it must be dropped from subsequent years' submittals. **For example, where a realignment occurs along a route and the old alignment no longer qualifies as part of the "Base Network," the old link(s) will be deleted and new links(s) will be added as needed.**

Code	Description
0	No Change
1	Changed - one or more data items on the Route Link record has changed
2	New Route Link
3	Deleted Route Link

Item 5 – Inventory Route Number (Length = 10)
The inventory route number, which is not necessarily the same as that posted along the roadway, is a number used to uniquely identify a route for inventory purposes. The inventory route number must be unique within a county, but it is recommended that it be unique within the State. This number can be alphanumeric, but must not contain blanks; it must be right justified in the field. Provide leading zeroes.

Item 6 – Inventory Subroute Number (Length = 2)
This number is used to uniquely identify portions of an inventory route within a county where certain conditions (KMPT/MPT equations, inventory route breaks, or KMPTs/MPTs that are adjusted at county boundaries) create a length of roadway with a duplicate KMPT/MPT or range of KMPTs/MPTs. A new subroute number must be assigned each time a duplicate KMPT/MPT or range of KMPTs/MPTs is encountered. These subroute numbers must only be unique within each county. In the absence of duplicate KMPTs/MPTs and previous to the first duplicate KMPT/MPT condition encountered, code zero.

Item 7 – Beginning Node Number (Length = 10)
This is the number of the first of two nodes of the link. This node is at the end of the link with the lowest KMPT/MPT.

Item 8 – Beginning Milepoint/Kilometerpoint (xxxx.xxx — code the decimal)(Length = 8)
This is the lowest KMPT/MPT of the link.

Item 9 – Ending Node Number (Length = 10)
This is the number of the last of two nodes of the link. This node is at the end of the link with the highest KMPT/MPT of the link.

Item 10 – Ending Milepoint/Kilometerpoint (xxxx.xxx — code the decimal)(Length = 8)
This is the highest KMPT/MPT of the link.

Signed Routes 1, 2, and 3: These three groups of three items define up to three signed route numbers assigned to a link. The priority of the signed routes shall be based on Item 11 below, where those with a non-zero lower code have the higher priority.

Items 11, 14, and 17 – Route Signing 1, 2, and 3 (Length = 1)
These codes specify the manner in which the highway segment is signed.

Code	Description
0	Not Signed or No More Signed Routes
1	Interstate
2	U.S.
3	State
4	Off-Interstate Business Markers
5	County
6	Township
7	Municipal
8	Parkway
9	None of the Above

Items 12, 15, and 18 – Route Qualifiers 1, 2 and 3 (Length = 1)
These codes specify the manner in which the highway segment is signed. Where more than one code is applicable, use the lower code excluding zero.

Code	Description
0	No Qualifier
1	Alternate
2	Business Route
3	Bypass
4	Spur
5	Loop
6	Proposed
7	Temporary
8	Truck Route
9	None of the Above

Items 13, 16, and 19 – Route Number 1, 2 and 3 (Length = 8)
Enter the signed route number (on the marker), right justified. Any alphabetic character prefixes or suffixes that cannot be identified with the Route Signing or Qualifier list of codes should be reported and abbreviated to fit into the field length, if necessary. Zero-fill if the route is unsigned or there are no more signed routes.

Item 20 – Street Name (Length = 30)
Enter a street, road, or highway name. This field need only be used when a signed route number is not available for use in describing the route. Otherwise, leave the field blank. If used, ensure that the name includes the proper suffix (street, place, court, etc.) to eliminate duplicate name possibilities.

For example: U.S. 5 Business Route and State 2 Truck Route are on the same link:

Item 11 = “2”	(U.S.)
Item 12 = “2”	(Business Route)
Item 13 = “00000005”	(Route Number)
Item 14 = “3”	(State)
Item 15 = “8”	(Truck Route)
Item 16 = “00000002”	(Route Number)

LRS Submittal Option 2 - LRSEDIT Files Plus Maps for New Links and Nodes

An LRSEDIT file for the complete base highway network with a copy of the LRSEDIT printed reports must be submitted along with maps depicting new links and nodes that did not exist on the NHPN. Maps must be labeled in accordance with instructions for coding inventory route and node maps under Option 1 above. Beginning and ending kilometerpoints/milepoints for the links must also be included.

LRS Submittal Option 3 - GIS Files

A complete GIS file encompassing the base highway network shall be submitted. This file shall contain all data required by Chapter V in a format agreed upon by the State and FHWA.

LRS Updates

After the initial reporting of LRS data, only updated information is required on an annual basis. LRS reporting status should be noted in the comment file, annually.

Technical Assistance

For technical assistance or further information regarding this chapter or about LRS, please contact Roger Petzold of the Federal Highway Administration; Phone: 202-366-4074, E-mail: roger.petzold@fhwa.dot.gov.

CHAPTER VI

UPDATING HPMS DATA

INTRODUCTION

This chapter provides information on updating basic HPMS data and the GIS/LRS data files and maps. HPMS data are to be updated on a regularly scheduled basis; continuous monitoring and updating are built into the process to assure the availability of timely and consistent information from all States.

The HPMS has been designed to permit updating with a minimum of effort. By systematically reporting and documenting changes as they occur, the data will not only be accurate and current, but States will also avoid periodic or sporadic workload requirements, which can be less efficient and disruptive. States are encouraged to set up ongoing mechanisms with both external (MPO, local authorities, etc.) and internal State highway agency offices to report changes as they occur. These should include internal State coordination between the HPMS staff and that of the State and MPOs, pavement management systems (PMS), traffic monitoring system, and other management systems and data collection activities.

GENERAL

All HPMS data are to be reported for the calendar year ending December 31. Updates to the HPMS data set may be made at any time for any data year; however, States are encouraged to make resubmittals on a timely basis when significant changes or errors are discovered.

UPDATING UNIVERSE AND SAMPLE DATA

Universe and sample data items are required to be reported annually in accordance with the guidelines outlined in Chapter IV. In general, traffic or condition-related data items are updated annually or on a 2- to 3-year cycle as indicated in the following table. Where a multi-year update cycle is shown, updated data may be collected all in one year or collection may be spread out over the several years in the cycle. Other data, such as year of improvement, lane width, shoulder type, etc., will change only as a result of physical improvement to the section.

All changes should be reported for the data year in which the change occurred; this is particularly important when reporting changes that result from highway improvements. The State should establish a mechanism that will provide these data to its road inventory system as soon as a construction project is completed and will ensure that all affected data items are updated at the same time.

Data Update Cycle

No.	Data Item	Update Cycle
1	Year of Data	Annual
2	State Code	No change permitted
3	Reporting Units – Metric or English	Change as necessary
4	County Code	No change permitted
5	Section Identification	Change as necessary
6	Is Standard Sample	Software coded
7	Is Donut Sample	Software coded
8	State Control Field	Change as necessary
9	Is Section Grouped?	Change as necessary
10	LRS Identification	Change as necessary
11	LRS Beginning Point	Change as necessary
12	LRS Ending Point	Change as necessary
13	Rural/Urban Designation	Change as necessary
14	Urbanized Area Sampling Technique	Change as necessary
15	Urbanized Area Code	Change as necessary
16	NAAQS Nonattainment Area Code	Change as necessary
17	Functional System Code	Change as necessary
18	Generated Functional System Code	Software calculated
19	National Highway System (NHS)	Change as necessary
20	Planned Unbuilt Facility	Change as necessary
21	Official Interstate Route Number	Change as necessary
22	Route Signing	Change as necessary
23	Route Signing Qualifier	Change as necessary
24	Signed Route Number	Change as necessary
25	Governmental Ownership	Change as necessary
26	Special Systems	Change as necessary
27	Type of Facility	Change as necessary
28	Designated Truck Route	Change as necessary
29	Toll	Change as necessary
30	Section Length	Change as necessary
31	Donut Area Sample AADT Volume Group Identifier	Software calculated from updated AADT; if AADT not reported, change as necessary
32	Standard Sample AADT Volume Group Identifier	Software calculated from updated AADT; if AADT not reported, change as necessary
33	AADT	Annual

No.	Data Item	Update Cycle
34	Number of Through Lanes	Change when section improved
35	Measured Pavement Roughness (IRI)	2-year cycle; also change when section improved
36	Present Serviceability Rating (PSR)	2-year cycle; also change when section improved
37	High Occupancy Vehicle (HOV) Operations	Change as necessary or when section improved
38-46	Highway Surveillance Systems	Change as necessary or when section improved
47	Sample Identifier	No change permitted
48	Donut Area Sample Expansion Factor	Software calculated
49	Standard Sample Expansion Factor	Software calculated
50	Surface/Pavement Type	Change when section improved
51	SN or D	Change when section improved
52	General Climate Zone	Software coded; change if necessary
53	Year of Surface Improvement	Change when section improved
54	Lane Width	Change when section improved
55	Access Control	Change when section improved
56	Median Type	Change when section improved
57	Median Width	Change when section improved
58	Shoulder Type	Change when section improved
59	Shoulder Width – Right	Change when section improved
60	Shoulder Width – Left	Change when section improved
61	Peak Parking	Change as necessary or when section improved
62	Widening Feasibility	Change as necessary
63-68	Curves by Class	Change when section improved
69	Horizontal Alignment Adequacy	Software coded when curve data reported; if curve data not reported, change when section improved
70	Type of Terrain	Change when section improved
71	Vertical Alignment Adequacy	Software coded when grade data reported; if grade data not reported, change when section improved
72-77	Grades by Class	Change when section improved
78	Percent Passing Sight Distance	Change when section improved
79	Weighted Design Speed	Software calculated
80	Speed Limit	Change as necessary
81	Percent Peak Single Unit Trucks	Change as necessary; 3-year maximum cycle
82	Percent Average Daily Single Unit Trucks	Change as necessary; 3-year maximum cycle

No.	Data Item	Update Cycle
83	Percent Peak Combination Trucks	Change as necessary; 3-year maximum cycle
84	Percent Average Daily Combination Trucks	Change as necessary; 3-year maximum cycle
85	K-Factor	3-year cycle
86	Directional Factor	3-year cycle
87	Number of Peak Lanes	Change as necessary or when section improved
88	Left Turning Lanes/Bays	Change as necessary or when section improved
89	Right Turning Lanes/Bays	Change as necessary or when section improved
90	Prevailing Type of Signalization	Change as necessary
91	Typical Peak Percent Green Time	Change as necessary
92	Number At-Grade Intersections -- Signals	Change as necessary or when section improved
93	Number At-Grade Intersections -- Stop Signs	Change as necessary or when section improved
94	Number At-Grade Intersections -- Other or No Controls	Change as necessary or when section improved
95	Peak Capacity	Software calculated
96	Volume/Service Flow Ratio (V/SF)	Software calculated
97	Future AADT	3-year cycle
98	Year of Future AADT	3-year cycle

UPDATING SUMMARY DATA

Population and land area data should be reported annually and reflect the current urbanized and small urban area boundaries as adjusted and approved by FHWA. Population estimates should be for the HPMS data reporting year; for those years between decennial censuses, the population estimate should be based on either the most recent census estimate or on the decennial Census figures adjusted for recent growth using other Federal, State, or local information.

Summary vehicle classification data should be reported annually. Information from the sites should be updated based on at least one-third of the panel each year. All functional systems must be monitored on a 3-year cycle.

UPDATING LRS DATA

After the initial reporting of LRS data, only updated information is required on an annual basis. LRS reporting status should be noted in the comment file, annually. Update inventory route, subroute number, beginning KMPT/MPT, and ending KMPT/MPT for universe and sample roadway sections annually on an as-needed basis (see Chapter IV, Items 5 and 10). Unless the lengths of the sections change or KMPTs/MPTs are reestablished, there will be no need to change this information. If the section lengths change or the KMPTs/MPTs are reestablished, the extent of kilometerpoint (milepoint) changes will depend on the LRS system used [i.e., how often kilometerpoints (milepoints) are reset to zero].

Network control LRS data should be updated in accordance with the following:

LRS Submittal Option 1; Maps and Computer Files

New inventory route and node maps for future submittals are only necessary if there are changes to the State's base highway network or LRS. Further, only those maps that cover the portion of the State's highway network that has changed need to be submitted. New or altered nodes and links should be shown along with adjacent, unchanged nodes and links. Once established, and at the State's request, FHWA will supply the necessary portions of the NHPN as either a paper map or a GIS data file for review and change purposes. Realignments or new routes that have been built also should be shown, color-coded by functional system. The alignment of new routes or realignments should be shown on these maps at a locational accuracy associated with a map scale of 1:100,000 or better, for digitizing purposes. The approximate alignment of proposed routes should be displayed.

The node data file and inventory route link data file need only be submitted if records have changed. The annual update need only consist of the records of those nodes and links that have been changed, added, or deleted. This will be indicated in Item 4, Record Status, for each record within each node data file and inventory route link data file. For those records that have changed, the appropriate items should be changed to reflect the current characteristics of the node or link. However, for any given change, the appropriate records for both the node and link files should be submitted (even if the change occurred only for the node or only within the link). A route that changes alignment, because of construction, should have its old links and nodes (only those affected by the realignment) deleted and new links and nodes added to reflect its new alignment. The same is true for a route that is realigned onto an existing highway that was not part of the base network for the previous year. New links and nodes should be added as appropriate.

LRS Submittal Option 2; LRSEDIT Files Plus Maps of New Links and Nodes

Complete LRSEDIT Files must be provided annually. Maps illustrating new links and nodes also must be provided. These maps should have a locational accuracy of at least that associated with 1:100,000 scale maps and must be adequate to support digitizing. Sufficient existing node and link detail must be included on the map(s) to enable FHWA to locate the new links and nodes.

LRS Submittal Option 3; State GIS Files

Complete GIS files must be provided annually; flags and narrative information must be provided as necessary to indicate data that has been added, deleted, or changed. FHWA should be contacted to discuss a State's plans for updating GIS submissions to ensure that FHWA receives appropriate data.

CHAPTER VII

SAMPLE SELECTION AND MAINTENANCE

INTRODUCTION

The purpose of this Chapter is to address a number of subjects related to the selection and maintenance of the HPMS sample and sample panels. The data reported for sampled roadway sections are the source of the condition, use, and operational information provided by the HPMS. Expanded sample data are used for apportionment of funds, for monitoring trends and impacts in performance data over time, and for analyses in support of national budgeting for highway improvements through the *Condition and Performance* reports to Congress. Selection and maintenance of an adequate, up-to-date HPMS sample should be a high priority, continuing activity.

Although developed for the HPMS standard sample, most of the following discussion applies equally for donut area supplementary sample panels; Appendix G contains additional discussion of the donut area sample panel.

SAMPLE PANEL CONSIDERATIONS

The HPMS sample includes the arterial and collector functional systems, excluding the rural minor collector system. While it is assumed that there is a “technically best” way to collect sample data, a sample design also must be simple and cost efficient to meet manpower and cost considerations; this involves tradeoffs. The required number of samples for HPMS are derived by formula from the normal dispersion characteristics of AADT values within a framework of preselected AADT groups (strata). The sample size requirements relate to the critical data element, AADT, whose values can be conveniently stratified. Information obtained from the existing sample or universe data in each State is used to optimize and maintain the sample panel.

Procedures for determining necessary sample size based on the analysis of existing data are described in this chapter. In order to obtain cost-effective, valid comparisons of system performance over time and to reduce technical effort, the sample was designed as a fixed sample panel. With a fixed sample panel, the same sections that are inventoried are then updated in future years on a cyclical basis. This means of obtaining data is efficient because:

1. The need for the periodic drawing of a complete new sample is eliminated.
2. The need to update or reinventory all data elements for every cycle is eliminated.
3. Only those data elements that change over time need be updated on a cyclical basis.

The length of the cycle is determined by the known statistical characteristics of individual elements, the intended use and accuracy needed, and the time and cost required to collect and report the data.

However, the use of fixed panel sections is not without disadvantages. These include:

- the possible loss of the sample's representativeness as the highway networks and traffic patterns change, and
- the inability to assess the correctness of the estimates by comparing them with those of a different sample.

Procedures have been developed to ensure the representativeness of the sample and FHWA has determined that the practicability of the fixed panel approach outweighs the disadvantages. HPMS sampling procedures are both simple and efficient and, if applied properly, the selected sample will achieve the predetermined levels of desired precision and yield an adequate sample for performance monitoring.

SAMPLE STRATIFICATION AND PRECISION LEVELS

Data needs vary for rural, small urban, and urbanized areas; this variation is reflected in the sample design. The design is capable of producing valid estimates of highway condition and operating and performance characteristics on a State-by-State basis. Rural and small urban functional systems are sampled on a statewide basis; although States with urbanized areas with less than 200,000 population that are not in an NAAQS nonattainment area may retain existing collective urbanized area samples at the State's option, all urbanized areas must be sampled individually in the future. A shift to individual urbanized area samples is encouraged for all States.

The sampling plan consists of the random selection of a panel of road sections within predetermined AADT volume groups (strata) for each functional system in the rural, small urban, and urbanized areas of the State. The stratification of sections (sampling units) into relatively homogeneous AADT volume groups produces estimates of greater accuracy with respect to VMT for a smaller number of samples at the functional system (summation) levels. Although stratification for sample selection is based on the critical data element AADT, tests have shown that AADT stratification is compatible with the sampling of nonvolume related data elements.

The required sample size is a function of the variability of AADT within a volume group, the functional system volume group precision level, and the number of sections available for sampling in the volume group (the universe). The term "precision level" is defined as the degree of confidence that the sampling error of a produced estimate will fall within a desired fixed range. For a precision level of 80-percent confidence with 10-percent allowable error (80-10), there is the probability that 80 times out of 100 the error of a data element estimate will be no greater than ±10 percent of its true value. The precision levels specified in Appendix C represent minimum FHWA requirements for rural, small urban, and urbanized area functional system volume groups. The precision levels determined for the sample design apply specifically to the individual volume strata. The sample size estimating procedures shown in Appendix D are used to determine the required number of samples to meet the target precision levels at the volume group level. The sample adequacy software described in Appendix K produces a table that contains a standard sample size estimation based on Appendix D criteria.

Sample size requirements by functional system will vary by State according to the total number of road sections, the number of predetermined volume groups, the validity of the State's AADT data, and the design precision level. The HPMS sample size requirements are more stringent for the arterial systems, where a higher level of precision is needed because of higher Federal interest. In rural, small urban, and collective urbanized areas, the sample sizes are based on a 90-5 precision level for the volume groups of the principal arterial system, 90-10 for the minor arterial system, and 80-10 for the collector (excluding minor collector) systems. The sample for individually sampled urbanized areas is broken into two major categories of precision levels:

1. For individual urbanized areas with a population of 200,000 or more and those that are in an NAAQS nonattainment area, the design precision levels are 90-10 for the arterial systems and 80-10 for the collector system.

2. For urbanized areas that are less than 200,000 population and are individually sampled, the design precision levels for individual volume strata are 80-10 or 70-15, depending upon the number of urbanized areas the State designates as individual sampling areas:
   - Those States with less than three should use a precision level of 80-10 for all functional systems.
   - Those with three or more may use the lower precision level of 70-15 for the minor arterial and collector systems and 80-10 for the principal arterial systems thereby requiring a smaller number of samples.

The statewide summation of individual urbanized functional system data element estimates will result in an overall precision level of at least 80-10.

The higher precision levels at the State level are necessary to obtain comparable urban and rural precision levels and to obtain precision levels that can adequately accommodate desired levels of accuracy for estimates of proportionate values as well as average and aggregate values. That is, although the HPMS sample is designed to measure AADT, the same samples are used to estimate the proportionate values of data such as pavement condition. Since the level of accuracy for estimated proportions is closely related to sample size, precision levels have been set sufficiently high to produce reasonable proportionate estimates at the functional system level.

PREPARATION FOR SAMPLE SELECTION

Before a sample can be drawn, the universe from which it is selected must be defined. This is very important since expansion factors, and the reliability of the expanded sample data, relate directly to the universe definition. Initial steps include:

- First, delimit the boundaries between rural, small urban, and urbanized areas using FHWA-approved, adjusted urban boundaries.
- Next, identify the functional system of all arterial and collector routes within each of these areas.
- Then, break the arterial and collector routes into logical roadway sections.
- Finally, assign all road sections in these functional systems to the predetermined AADT groups shown in Appendix C.

An AADT volume group assignment is required for all roadway sections on functional systems subject to sampling (all but rural minor collector and rural and urban local). Assigning sections to proper volume groups and maintaining proper volume group assignments is an important step. Because of economic growth and development, AADT growth may require periodic adjustments to volume group assignments over time. The HPMS software will assign a volume group for each section where an AADT is provided. Maintaining accurate volume groups requires States and other data providers to maintain comprehensive, high quality, traffic count programs (see Appendix F).

If volume groups other than the predetermined volume groups shown in Appendix C are selected, the AADT limits of these volume groups must be reported to FHWA, and the State will need to assign each section to the appropriate volume group.

Each HPMS section should be relatively homogeneous as to geometrics, traffic volume, cross section, and condition, and should be long enough to constitute a logical section for various analyses such as determining highway investment requirements. In general:

- Rural section lengths should range from 0.5 to 16.1 kilometers (0.3 to 10.0 miles)
- Urban access controlled facility section lengths should usually not exceed 8.0 kilometers (5.0 miles)
- All other urban section lengths should range from 0.2 to 4.8 kilometers (0.1 to 3.0 miles).

These suggested lengths are intended to keep the sample normalized on a national basis. Shorter lengths may be warranted where there are nonhomogeneous roadway elements; longer sections reduce the number of universe sections and result in a somewhat smaller number of initial samples. However, longer sections may have to be split in later years in order to maintain sample homogeneity; this will increase the number of universe sections and may result in an increase in the required number of samples.

Finally, it is important to precisely document the exact location of each sampled section to assure that yearly and cyclical updates, field reviews, traffic counts, etc., are performed on the appropriate roadway sections.

CALCULATION OF EXPANSION FACTORS

The purpose of the HPMS sample panel is to provide an expandable base for rural, small urban and urbanized area data in each State, stratified by functional system and traffic volume group. An expansion factor is calculated for each volume stratum within each functional system. This is accomplished by dividing the total kilometers (miles) in the stratum by the kilometers (miles) included in that stratum's sample. As noted above, the total universe length in each stratum is a known value based on the AADT volume group identifier. Expansion factors are calculated by the HPMS software for each sample section. The expansion factor allows sample data to be expanded to represent entire functional systems for rural, small urban, and urbanized areas.

SAMPLING RURAL AND SMALL URBAN AREAS

Both rural and small urban area data are sampled on a statewide basis, stratified only by functional system and volume group. The volume group for each road section in the sampling universe must be identified using the tables in Appendix C before sample selection can begin. The number of sections to be included in the sample is determined using the calculation procedure in Appendix D. A minimum of three unique sample sections is required for each volume group; if less than three universe sections exist in a volume group, they must all be sampled and the expansion factor will be 1.000. Sections should be selected from the universe of each functional system and volume group using a random number table or random number generation computer software, until the required number of samples is reached.

SAMPLING INDIVIDUAL URBANIZED AREAS

Urbanized area data are sampled on an individual area basis stratified by functional system and volume group. Each State must individually sample new urbanized areas regardless of population size. However, the State has the option to determine which of the existing urbanized areas it will retain in existing collective samples. For each individually sampled urbanized area, the volume group for each road section in the sampling universe must be identified using the tables in Appendix C before sample selection can begin. Where AADTs higher than those contained in this table are encountered, the State may add higher volume groups that contain a range similar to that for the highest volume group shown in the table for the appropriate functional system. However, States electing this option will have to assign all sections to appropriate volume groups. As an alternate, the State may leave the sections in the highest volume group.

The number of sections to be included in the sample is determined using the calculation procedure in Appendix D. As with rural and small urban areas, sections should be selected from the universe of each functional system and volume group using a random number table or random number generation computer software, until the required number of samples is reached; a minimum of three sections per stratum is required.

Unless part of an existing collective sample, each State must sample its part of a multi-State urbanized area individually. All portions of multi-State urbanized areas must be sampled. When sampled as individual areas, the sample in each State should not be less than its pro rata share for the entire urbanized area by functional system and volume group nor in any case less than one section per applicable volume group. If length does not exist in a particular volume group in one (or more) portion(s) of a multi-State urbanized area, all of the sampling should take place in the State(s) where the length does exist. In such areas, expansion factors must be calculated separately for each State's portion. To ensure a consistent sampling approach, States having multi-State urbanized areas are urged to coordinate with the appropriate neighboring State(s) so that all portions of an urbanized area are sampled in the same manner.

An individual sampling approach must be applied to all parts of multi-State urbanized areas if expanded estimates are desired for the complete urbanized area. If even one State includes its portion of a multi-State area in the collective category, then no sample based estimates for the complete urbanized area are possible.

SAMPLING COLLECTIVE URBANIZED AREAS

In the future, all urbanized areas must be sampled individually, and state are encouraged to eliminate all existing urbanized area collective samples as soon as possible.

As with individually sampled urbanized areas, the volume group for each road section in the grouped sample universe must be identified using the tables in Appendix C before sample selection can begin. The number of sections to be included in the sample is determined using the calculation procedure in Appendix D. Sections should be selected from the universe of each functional system and volume group using a random number table or random number generation computer software, until the required number of samples is reached; a minimum of three sections per stratum is required.

SAMPLE MAINTENANCE

An HPMS sample adequacy review should be performed on a periodic basis as part of a State's sample maintenance activities; a 3-year sample review cycle is strongly recommended. The review should be completed shortly after the annual submittal of the HPMS data set; this permits the data provider to assess the adequacy of the sample in time to make changes for the next reporting cycle. A number of elements should be considered when making a review of HPMS sample adequacy. These should include not only the assessment of number of samples by volume group, but also checks for potential sample biases.

When conducting a sample adequacy review, the State also should check for biases that may have been inadvertently introduced into the sample. Although the HPMS sample was designed as a fixed panel sample, additions, deletions, and other changes may have been made to the sample to account for system and other changes that occurred over time. And, although changes to the HPMS sample are to be made on a random basis, this may or may not have been a closely observed practice.

As a result, sample bias may have been introduced in areas such as samples on State versus non-State owned roads, subarea biases by highway district or county, or nonrandom selection of adjacent roadway sections as new samples. Some of these biases may be disclosed by comparing the number of miles sampled; for instance, the percent of State owned miles sampled compared with the percent of non-State owned miles sampled. Others may require a more detailed examination of the sample and its distribution; are samples clustered in groups on the same facility, for instance. A periodic review of sample adequacy provides an opportunity to identify if any of these problems exist; as further changes are made to the HPMS sample, any biased sample selection procedures should be eliminated to improve sample randomness.

Need for Sample Panel Adjustments

There are any number of occurrences that may result in a need to reconsider the suitability of the existing sample panel. Some of the more common reasons for considering sample panel adjustments include:

- The decennial census of population is likely to require changes in HPMS sample panels. The sampling basis may need to change because the numbers of small urban areas and individual urbanized areas may change, and/or the FHWA approved, adjusted Census urban boundaries of existing urban areas may be altered.
- The addition of new areas and the expansion of current urban boundaries are likely to require the functional reclassification of roadways within the new boundaries. This will in turn likely require transferring universe and sample sections from one area's panel to another and randomly drawing additional samples to satisfy urban area requirements. Also, the loss of samples caused by movement from rural to small urban or from rural or small urban to urbanized areas may cause a deficiency in the rural or small urban area panels.
- Changes in the existing functional system length and HPMS sample panels are likely to result from functional reclassification, non-Census related changes in urban boundaries, or new road construction.
- Migration of sections among and between volume groups may also result in a need to change HPMS sample panels. Each volume group contained in a functional system is a separate sampling universe; normally, over the short term (less than 3 years), there should be only minor changes in sample section and universe length assignments to specific volume groups as a result of traffic increases or decreases. Universe volume group information for each roadway section must be kept up to date so that correct volume group reassignments can be made (see Appendix C).

A thorough sample adequacy review, conducted on a 3-year cycle basis, provides an opportunity to update the HPMS sample panels when necessary to meet the changed conditions reflected above.

Making Sample Panel Adjustments

Sample panel adjustments should be made as necessary upon completion of a sample adequacy review; use of a 3-year cycle will minimize the burden of completing this task. The following general procedures should be considered when adjusting sample panels:

- Functionally reclassify roadway sections that have moved from rural areas into new or expanded urban/urbanized areas or out of contracting urban areas into rural areas; use appropriate classification criteria and good engineering judgment to determine the extent of change warranted.
- Stratify the reclassified roadway sections within these same areas into traffic volume groups consistent with the groups established for the latest HPMS sample.
- Transfer rural, urban, or urbanized sample sections that have moved from one area type to another into the appropriate functional systems and volume groups in the new panel.
- Calculate the required number of standard samples required for the revised rural, small urban, and urbanized area panels in accordance with Appendix D procedures and select additional samples where necessary.

In using these general procedures, the user should keep in mind that:

- When small urban or urbanized areas contract in size, changes to small urban or rural sample panels will occur; universe and sample sections affected by such changes should be assigned to the correct functional system and volume group in the new panel.
- Make adjustments to standard and donut area sample panels independently. It is better to update the standard sample panels prior to updating the donut area sample panels, since existing standard samples in the donut areas become donut area samples; in general, the same procedures apply (see Appendix G).
- If a new urbanized nonattainment area is designated by EPA, a new donut area sample must be drawn for that nonattainment area in accordance with the procedures in Appendix G.

Selecting Additional Samples

The selection of additional sample sections for a given volume group is straightforward for most sample panel updates. Basically, the number of existing sample sections is compared to the required number as determined from the Appendix D procedures, and additional sample sections are randomly drawn from the nonsampled universe sections in the same volume group to cover any shortfalls. Again, maintaining accurate volume groups requires States and other data providers to maintain comprehensive, high quality, traffic count programs (see Appendix F). This procedure is to be used for the standard sample panels in rural, small urban and individually sampled urbanized areas, and for the donut areas of nonattainment areas; it also is to be used when newly designated urbanized areas are sampled as individual areas.

Sample Permanence

Once a roadway section has been selected for a sample panel, it must be maintained as a sample regardless of changes in volume group assignment, functional system, or geographic area. Sample sections transferred to other geographic areas become part of the sample base for those areas. Samples may be dropped in cases where a roadway is truly abandoned and not relocated, where sample sections are reclassified to the rural or urban local or rural minor collector functional systems, or where sample sections are dropped from use as a result of a sample reduction plan. When samples are deleted, the State must submit a list of the sample numbers, the reasons for the deletions, and where the deletions will occur.

Deleting Samples

Since the standard sample panel has been in existence for some time, the addition of samples and the movement of universe and sample sections from one volume group to another are likely to have caused over sampling in some volume groups. Significant oversampling is not encouraged because of cost and efficiency impacts; sample reductions should be considered a normal part of sample maintenance. Before proceeding with a sample reduction exercise, the State should prepare a sample reduction plan and provide it to the FHWA for evaluation. A sample reduction plan should take account of the following:

1. All sampling criteria must be met; sample size requirements in Appendix D must be maintained for each standard sample functional system.
2. Sample AADT and universe section volume group data must be up to date and accurate.
3. Individual volume group reductions of less than three sample sections in any volume group should not be considered.
4. Random deletion of the samples within each over sampled volume group is required.
5. The three samples per volume group minimum must be maintained.
6. Trends of sample/universe section migration among volume groups should be examined; volume groups that continually gain samples may warrant keeping a few excess samples.
7. An expansion factor maximum of 100.000 should be observed.
8. A State using the HPMS analytical package or the HPMS data base for other purposes may want to keep an oversampled sample panel intact or consider using higher precision levels.
9. The sample reduction process may require more effort than the apparent resulting benefit of maintaining fewer samples; however, a periodic review and adjustment of the sample is needed to maintain the overall viability of the HPMS sample program.
10. A sample reduction should be considered as part of the 3-year sample adequacy review.

Updating Expansion Factors

When updating sample panels, any change in sample length and/or the length of the sampling frame (the universe) requires updating the expansion factors related to affected volume groups. Expansion factors are recalculated before every HPMS submittal to ensure that all changes to volume groups (both universe and sample), whatever the cause, have been properly accommodated. Expansion factor recalculation is one of the final data preparation steps when the HPMS submittal software is used.

A Tabular Summary

The following table provides an overview of conditions which generally require making changes to HPMS sample panels, both standard and donut area. It is divided into those changes triggered either directly or indirectly by Bureau of Census actions, or by changes unrelated to Census actions. The table outlines the “causes” for potential sample panel change and the “Recommendations” to deal with the change.

CAUSE	RECOMMENDATION
CENSUS RELATED	
New Small Urban Areas (Rural to Small Urban)	Adjust all rural sample section records within the new area to urban requirements. Verify statewide rural and small urban area sample and universe bases and select additional samples as necessary.
New Urbanized Areas (Small Urban and/or Rural to Urbanized)	Adjust all rural and small urban area sample section records within the new area to urbanized area requirements. Procedures for drawing new standard samples for individual panels are discussed above. Procedures for drawing donut area samples are discussed in Appendix G. Verify all sample and universe bases and select additional samples as necessary.
Expansion of the Adjusted Boundaries of Small Urban or Urbanized Areas (Rural to Small Urban and Rural and/or Small Urban to Individual Urbanized)	Adjust all affected rural sample section records to urban requirements. Verify all affected sample and universe bases and select additional samples as necessary.
Functional System Reclassification--Any Area	Reassign reclassified sections (universe and sample) to appropriate areas and volume groups. Sample new sections as necessary to maintain required volume group precision levels.
Losses in Urban Population	No action until Census area designation changes.
Major Revision of Boundaries Based on New Census	Redraw sample panel and include old samples, if possible.
Changes or Additions to Nonattainment Area(s).	Updates to the donut area samples are made based on the procedures in Appendix G.
NON-CENSUS RELATED	
New Length by Functional System	Verify sample and universe base; sample new sections, if necessary.
Functional System Reclassification in Any Area	In addition to the movement of sections because of reclassification, there may be a need for possible volume group changes for universe and/or sample sections, precision level changes, and additional samples.
Volume Group Reassignment of Sections	Reassign sample sections but no further action is needed if changes are minor; if changes are major, verify volume group sample and universe bases for all affected volume groups and add samples, if necessary.
Expansion Factor	Adjust expansion factor values for sample section records in the affected group.

Splitting Samples

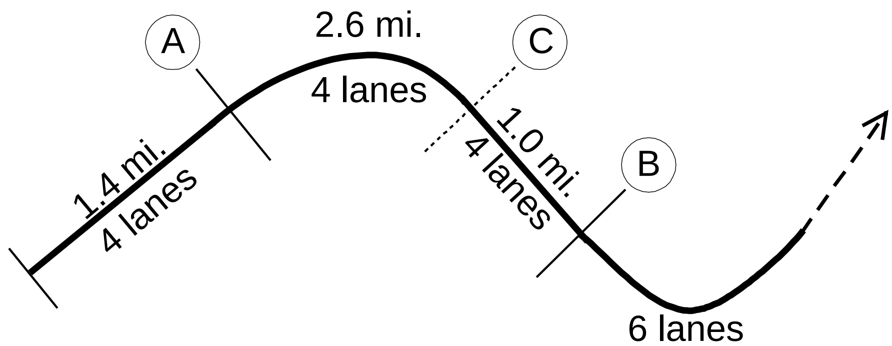
Sample sections should be split only when significant HPMS related changes in an existing sample occur. The most critical reasons for splitting samples involve changes in traffic (AADT) on the section, county code, functional system, urban/rural/urbanized status, and number of lanes. Many times these changes are the product of adjacent land development, which may result in the improvement of a portion of an existing sample, an increase in traffic on the improved portion, and/or the inclusion of the improved portion in an urbanized area boundary. In general, a change in any of the following key HPMS data items on an existing sample section should result in splitting an HPMS sample:

Item Number	Data Item
4	County Code
13	Rural/Urban Designation
15	Urbanized Area Code
16	NAAQS Nonattainment Area Code
17	Functional System
19	National Highway System
25	Governmental Ownership
26	Special Systems
27	Type of Facility
33	AADT
34	Number of Through Lanes

It may be necessary to split HPMS samples when there are changes in other HPMS data items; however, the State needs to make a reasoned judgment of the particular case beyond these minimum specifications. In most cases, for changes in other HPMS data items on existing sample sections, it is more than adequate to code the predominant or typical condition on the existing sample section and retain the entire sample. If a shoulder type, for instance, is changed on a portion of an existing sample section, it is acceptable to code the resulting predominant type of shoulder on the entire section in lieu of splitting the sample. If part of a sample is improved and the remaining portion is to be improved in the next construction season, it is likewise acceptable to code the predominant condition and retain the entire sample. Samples should not be split for changes in non-HPMS related State inventory items, such as guardrail changes or highway district boundary, etc.

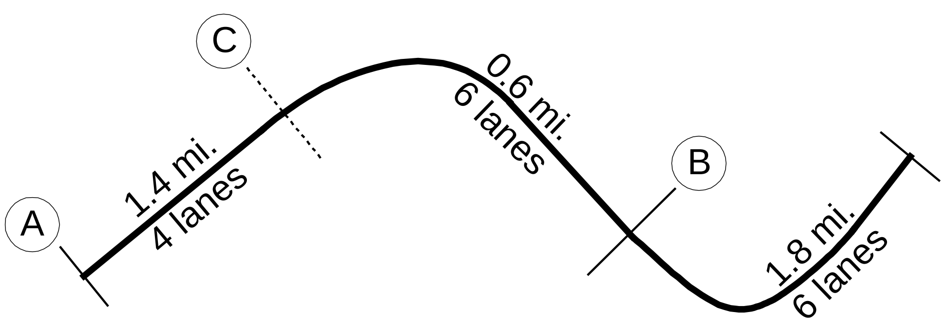
When splitting an existing sample section, the State should select the portion to remain as the sample based either on length - keep the longest portion - or by random pick; the selected portion becomes the sample and retains the existing sample identifier. Although FHWA suggests that the longest section be retained as the sample, either is acceptable. The remaining portion should be converted to a universe section or merged with an adjoining universe section. It is important that all count information is adjusted to reflect actual conditions on the retained sample section. Two examples follow.

Splitting Samples



Existing sample section (A-B) with 4 lanes = 2.6 mi.
Urban/rural change = 1.0 mi.
New universe section (C-B)
Remaining sample now = 1.6 mi. (A-C)

Splitting Samples



Existing sample section (A-B) = 2.0 mi.
Major improvement (add 2 lanes) = 0.6 mi.
Merge (C-B) with adjacent universe section (1.8 mi.) for total = 2.4 mi.
Sample section now = 1.4 mi. (A-C)

ELIMINATING SHORT SAMPLE SECTIONS

As part of sample maintenance activities, existing samples should be reviewed to see if they can be deleted or recombined with adjacent sample sections. In the past, excessive splitting of HPMS sample sections has resulted in the accumulation of many short adjacent sample sections. Adjacent short samples not meeting minimum length requirements should be recombined into longer sample sections if they have similar roadway characteristics and the key data items listed under the "Splitting Samples" discussion are the same. Excessive short samples resulting from previous sample splits can also be considered for deletion if HPMS-critical roadway characteristics are the same for a number of adjacent samples. In this case, the State may wish to retain the longest sample and recombine the remaining samples with an adjacent universe section or merge them into a new universe section. The sample section to be retained can also be selected randomly. Either way, a reduction in an excessive number of short samples may save the State financial and personnel resources and will improve sample representation.

APPENDIX A

TABLE OF FEDERAL INFORMATION PROCESSING STANDARD (FIPS) CODES FOR STATES
(FIPS PUB 5-2)

State	Code	State	Code
Alabama	01	Nevada	32
Alaska	02	New Hampshire	33
Arizona	04	New Jersey	34
Arkansas	05	New Mexico	35
California	06	New York	36
Colorado	08	North Carolina	37
Connecticut	09	North Dakota	38
Delaware	10	Ohio	39
District of Columbia	11	Oklahoma	40
Florida	12	Oregon	41
Georgia	13	Pennsylvania	42
Hawaii	15	Rhode Island	44
Idaho	16	South Carolina	45
Illinois	17	South Dakota	46
Indiana	18	Tennessee	47
Iowa	19	Texas	48
Kansas	20	Utah	49
Kentucky	21	Vermont	50
Louisiana	22	Virginia	51
Maine	23	Washington	53
Maryland	24	West Virginia	54
Massachusetts	25	Wisconsin	55
Michigan	26	Wyoming	56
Minnesota	27	American Samoa	60
Mississippi	28	Guam	66
Missouri	29	Northern Marianas	69
Montana	30	Puerto Rico	72
Nebraska	31	Virgin Islands	78

APPENDIX B

URBANIZED AREA CODES

Urbanized Area	Code
Alabama	
Anniston	254
Auburn-Opelika	294
Birmingham	035
Columbus (GA-AL)	109
Decatur	295
Dothan	296
Florence	255
Gadsden	192
Huntsville	184
Mobile	067
Montgomery	115
Tuscaloosa	183
Alaska	
Anchorage	256
Arizona	
Flagstaff	420
Phoenix	033
Tucson	073
Yuma (AZ-CA)	287
Arkansas	
Fayetteville-Springdale	297
Fort Smith (AR-OK)	202
Little Rock-North Little Rock	092
Memphis (TN-AR-MS)	034
Pine Bluff	219
Texarkana (TX-AR)	211
California	
Antioch-Pittsburg	257
Bakersfield	117
Chico	298
Davis	381
Fairfield	299
Fresno	080
Hemet-San Jacinto	300
Hesperia-Apple Valley-Victorville	391
Indio-Coachella	396
Lancaster-Palmdale	301

Urbanized Area	Code
Lodi	400
Lompoc	402
Los Angeles	002
Merced	380
Modesto	234
Napa	302
Oxnard-Ventura	224
Palm Springs	303
Redding	304
Riverside-San Bernardino	048
Sacramento	042
Salinas	229
San Diego	023
San Francisco-Oakland	006
San Jose	032
San Luis Obispo	410
Santa Barbara	187
Santa Cruz	258
Santa Maria	305
Santa Rosa	235
Seaside-Monterey	236
Simi Valley	237
Stockton	119
Vacaville	417
Visalia	306
Watsonville	419
Yuba City	307
Yuma (AZ-CA)	287
Colorado	
Boulder	238
Colorado Springs	153
Denver	024
Fort Collins	308
Grand Junction	309
Greeley	310
Longmont	403
Pueblo	149
Connecticut	
Bridgeport-Milford	051

Urbanized Area	Code
Bristol	239
Danbury (CT-NY)	240
Hartford-Middletown	047
New Britain	154
New Haven (064)-Meriden (212)	406
New London-Norwich	259
Norwalk	176
Springfield (MA-CT)	043
Stamford (CT-NY)	103
Waterbury	118
Worcester (MA-CT)	076
Delaware	
Dover	387
Wilmington (DE-NJ-MD-PA)	063
District of Columbia	
Washington (DC-MD-VA)	008
Florida	
Daytona Beach	260
Deltona	385
Fort Lauderdale-Hollywood-Pompano Beach	058
Fort Myers-Cape Coral	261
Fort Pierce	311
Fort Walton Beach	312
Gainesville	241
Jacksonville	050
Kissimmee	398
Lakeland	262
Melbourne-Palm Bay	263
Miami-Hialeah	021
Naples	313
Ocala	314
Orlando	087
Panama City	315
Pensacola	125
Punta Gorda	408
Sarasota-Bradenton	264
Spring Hill	412
Stuart	413
Tallahassee	220
Tampa (059)-St. Petersburg (057)-Clearwater	415
Titusville	416
Vero Beach	418
West Palm Beach-Boca Raton-Delray Beach	097
Winter Haven	316
Georgia	
Albany	209

Urbanized Area	Code
Athens	317
Atlanta	025
Augusta (GA-SC)	131
Brunswick	382
Chattanooga (TN-GA)	086
Columbus (GA-AL)	109
Macon	143
Rome	318
Savannah	100
Warner Robins	319
Hawaii	
Honolulu	052
Kailua	320
Idaho	
Boise City	217
Idaho Falls	395
Pocatello	321
Illinois	
Alton	265
Aurora	292
Beloit (WI-IL)	291
Bloomington-Normal	227
Champaign-Urbana	181
Chicago-Northwestern IN (IL-IN)	003
Crystal Lake	384
Davenport-Rock Island-Moline (IA-IL)	074
Decatur	169
Dubuque (IA-IL)	206
Elgin	293
Joliet	138
Kankakee	323
Peoria	093
Rockford	099
Round Lake Beach-McHenry (IL-WI)	379
Springfield	146
St. Louis (MO-IL)	011
Indiana	
Anderson	223
Bloomington	324
Chicago-Northwestern IN (IL-IN)	003
Elkhart-Goshen	325
Evansville (IN-KY)	114
Fort Wayne	094
Indianapolis	029
Kokomo	326
Lafayette-West Lafayette	222

Urbanized Area	Code
Louisville (KY-IN)	031
Muncie	182
South Bend-Mishawaka (IN-MI)	077
Terre Haute	178
Iowa	
Cedar Rapids	148
Davenport-Rock Island-Moline (IA-IL)	074
Des Moines	071
Dubuque (IA-IL)	206
Iowa City	327
Omaha (NE-IA)	046
Sioux City (IA-NE-SD)	156
Waterloo-Cedar Falls	150
Kansas	
Kansas City (MO-KS)	019
Lawrence	328
St. Joseph (MO-KS)	179
Topeka	134
Wichita	062
Kentucky	
Cincinnati (OH-KY)	017
Clarksville (TN-KY)	280
Evansville (IN-KY)	114
Huntington-Ashland (WV-KY-OH)	105
Lexington-Fayette	144
Louisville (KY-IN)	031
Owensboro	242
Louisiana	
Alexandria	266
Baton Rouge	088
Houma	329
Lafayette	218
Lake Charles	171
Monroe	180
New Orleans	022
Shreveport	085
Slidell	411
Maine	
Bangor	330
Lewiston-Auburn	196
Portland	145
Portsmouth-Dover-Rochester (NH-ME)	283
Maryland	
Annapolis	331

Urbanized Area	Code
Baltimore	012
Cumberland (MD-WV)	285
Frederick	388
Hagerstown (MD-PA-WV)	284
Washington (DC-MD-VA)	008
Wilmington (DE-NJ-MD-PA)	063
Massachusetts	
Boston	007
Brockton	147
Fall River (MA-RI)	130
Fitchburg-Leominster	189
Hyannis	394
Lawrence-Haverhill (MA-NH)	104
Lowell (MA-NH)	136
New Bedford	127
Pittsfield	199
Providence-Pawtucket (RI-MA)	026
Springfield (MA-CT)	043
Taunton	332
Worcester (MA-CT)	076
Michigan	
Ann Arbor	142
Battle Creek	267
Bay City	186
Benton Harbor	333
Detroit	005
Flint	065
Grand Rapids	061
Holland	392
Jackson	190
Kalamazoo	141
Lansing-East Lansing	102
Muskegon	162
Port Huron	334
Saginaw	123
South Bend-Mishawaka (IN-MI)	077
Toledo (OH-MI)	044
Minnesota	
Duluth (MN-WI)	113
Fargo-Moorhead (ND-MN)	188
Grand Forks (ND-MN)	289
La Crosse (WI-MN)	243
Minneapolis-St. Paul	013
Rochester	244
St. Cloud	268

Urbanized Area	Code
Mississippi	
Biloxi-Gulfport	231
Hattiesburg	335
Jackson	112
Memphis (TN-AR-MS)	034
Pascagoula	336
Missouri	
Columbia	245
Joplin	337
Kansas City (MO-KS)	019
Springfield	157
St. Joseph (MO-KS)	179
St. Louis (MO-IL)	011
Montana	
Billings	204
Great Falls	210
Missoula	338
Nebraska	
Lincoln	121
Omaha (NE-IA)	046
Sioux City (IA-NE-SD)	156
Nevada	
Las Vegas	170
Reno	191
New Hampshire	
Lawrence-Haverhill (MA-NH)	104
Lowell (MA-NH)	136
Manchester	165
Nashua	246
Portsmouth-Dover-Rochester (NH-ME)	283
New Jersey	
Allentown-Bethlehem-Easton (PA-NJ)	068
Atlantic City	128
New York-Northeastern NJ (NY-NJ)	001
Philadelphia (PA-NJ)	004
Trenton (NJ-PA)	069
Vineland-Millville	233
Wilmington (DE-NJ-MD-PA)	063
New Mexico	
Albuquerque	070
El Paso (TX-NM)	066
Las Cruces	339
Santa Fe	340

Urbanized Area	Code
New York	
Albany-Schenectady-Troy	041
Binghamton	110
Buffalo-Niagara Falls	016
Danbury (CT-NY)	240
Elmira	269
Glens Falls	341
Ithaca	397
New York-Northeastern NJ (NY-NJ)	001
Newburgh	342
Poughkeepsie	270
Rochester	039
Stamford (CT-NY)	103
Syracuse	056
Utica-Rome	089
North Carolina	
Asheville	193
Burlington	271
Charlotte	082
Durham	173
Fayetteville	221
Gastonia	272
Goldsboro	344
Greensboro	132
Greenville	390
Hickory	345
High Point	195
Jacksonville	346
Kannapolis	343
Raleigh	163
Rocky Mount	409
Wilmington	226
Winston-Salem	124
North Dakota	
Bismarck-Mandan	347
Fargo-Moorhead (ND-MN)	188
Grand Forks (ND-MN)	289
Ohio	
Akron	040
Canton	079
Cincinnati (OH-KY)	017
Cleveland	010
Columbus	030
Dayton	038
Hamilton	168
Huntington-Ashland (WV-KY-OH)	105

Urbanized Area	Code
Lima	198
Lorain-Elyria	116
Mansfield	228
Middletown	348
Newark	349
Parkersburg (WV-OH)	273
Sharon (PA-OH)	290
Springfield	167
Steubenville-Weirton (OH-WV-PA)	177
Toledo (OH-MI)	044
Wheeling (WV-OH)	155
Youngstown-Warren	049
Oklahoma	
Fort Smith (AR-OK)	202
Lawton	200
Oklahoma City	045
Tulsa	060
Oregon	
Eugene-Springfield	161
Longview (WA-OR)	286
Medford	351
Portland-Vancouver (OR-WA)	027
Salem	225
Pennsylvania	
Allentown-Bethlehem-Easton (PA-NJ)	068
Altoona	175
Erie	095
Hagerstown (MD-PA-WV)	284
Harrisburg	083
Johnstown	159
Lancaster	164
Monessen	352
Philadelphia (PA-NJ)	004
Pittsburgh	009
Pottstown	407
Reading	107
Scranton--Wilkes-Barre	281
Sharon (PA-OH)	290
State College	353
Steubenville-Weirton (OH-WV-PA)	177
Trenton (NJ-PA)	069
Williamsport	274
Wilmington (DE-NJ-MD-PA)	063
York	152

Urbanized Area	Code
Puerto Rico	
Aguadilla	376
Arecibo	377
Caguas	247
Cayey	383
Humacao	393
Mayaguez	216
Ponce	215
San Juan	214
Vega Baja-Manati	378
Rhode Island	
Fall River (MA-RI)	130
Newport	354
Providence-Pawtucket (RI-MA)	026
South Carolina	
Anderson	355
Augusta (GA-SC)	131
Charleston	108
Columbia	106
Florence	356
Greenville	126
Myrtle Beach	404
Rock Hill	357
Spartanburg	275
Sumter	414
South Dakota	
Rapid City	358
Sioux City (IA-NE-SD)	156
Sioux Falls	194
Tennessee	
Bristol (TN-VA)	288
Chattanooga (TN-GA)	086
Clarksville (TN-KY)	280
Jackson	359
Johnson City	360
Kingsport (TN-VA)	276
Knoxville	098
Memphis (TN-AR-MS)	034
Nashville	054
Texas	
Abilene	166
Amarillo	120
Austin	090
Beaumont	135
Brownsville	248

Urbanized Area	Code
Bryan-College Station	249
Corpus Christi	096
Dallas-Fort Worth	282
Denton	386
El Paso (TX-NM)	066
Galveston	137
Harlingen	201
Houston	015
Killeen	277
Laredo	205
Lewisville	399
Longview	361
Lubbock	122
McAllen-Edinburg-Mission	230
Midland	197
Odessa	174
Port Arthur	139
San Angelo	208
San Antonio	028
Sherman-Denison	232
Temple	362
Texarkana (TX-AR)	211
Texas City	250
Tyler	213
Victoria	363
Waco	140
Wichita Falls	151
Utah	
Logan	401
Ogden	133
Provo-Orem	203
Salt Lake City	053
Vermont	
Burlington	364
Virginia	
Bristol (TN-VA)	288
Charlottesville	365
Danville	366
Fredericksburg	389
Kingsport (TN-VA)	276
Lynchburg	207
Norfolk (036)-Virginia Beach-Newport News (084)	405
Petersburg	251
Richmond	055
Roanoke	129

Urbanized Area	Code
Washington (DC-MD-VA)	008
Washington	
Bellingham	367
Bremerton	368
Longview (WA-OR)	286
Olympia	369
Portland-Vancouver (OR-WA)	027
Richland-Kennewick-Pasco	278
Seattle	020
Spokane	075
Tacoma	078
Yakima	279
West Virginia	
Charleston	101
Cumberland (MD-WV)	285
Hagerstown (MD-PA-WV)	284
Huntington-Ashland (WV-KY-OH)	105
Parkersburg (WV-OH)	273
Steubenville-Weirton (OH-WV-PA)	177
Wheeling (WV-OH)	155
Wisconsin	
Appleton-Neenah	252
Beloit (WI-IL)	291
Duluth (MN-WI)	113
Eau Claire	370
Green Bay	158
Janesville	371
Kenosha	185
La Crosse (WI-MN)	243
Madison	111
Milwaukee	014
Oshkosh	253
Racine	160
Round Lake Beach-McHenry (IL-WI)	379
Sheboygan	372
Wausau	373
Wyoming	
Casper	374
Cheyenne	375

APPENDIX C

VOLUME GROUPS AND PRECISION LEVELS

Table C-1. Standard Sample Volume Groups and Precision Levels

RURAL AREAS				
AADT Volume Group	Interstate	Other Principal Arterial	Minor Arterial	Major Collector
	(90-5)	(90-5)	(90-10)	(80-10)
01	0- 9,999	0- 4,999	0- 2,499	0- 2,499
02	10,000- 19,999	5,000- 9,999	2,500- 4,999	2,500- 4,999
03	20,000- 29,999	10,000- 14,999	5,000- 9,999	5,000- 9,999
04	30,000- 39,999	15,000- 19,999	10,000-19,999	10,000-19,999
05	40,000- 49,999	20,000- 29,999	20,000-29,999	20,000-29,999
06	50,000- 59,999	30,000- 39,999	30,000-39,999	30,000-39,999
07	60,000- 69,999	40,000- 49,999	40,000-49,999	40,000-49,999
08	70,000- 79,999	50,000- 59,999	50,000-59,999	50,000-59,999
09	80,000- 89,999	60,000- 69,999	60,000-69,999	60,000-69,999
10	90,000-104,999	70,000- 84,999	70,000-79,999	70,000-79,999
11	105,000-119,999	85,000- 99,999	80,000-89,999	80,000-89,999
12	120,000-134,999	100,000-114,999	90,000-99,999	90,000-99,999
13	> or = 135,000	> or = 115,000	> or = 100,000	> or = 100,000

Table C-2. Standard Sample Volume Groups and Precision Levels

SMALL URBAN AREAS					
AADT Volume Group	Interstate	Other Freeways and Expressways	Other Principal Arterial	Minor Arterial	Collector
	(90-5)	(90-5)	(90-5)	(90-10)	(80-10)
01	0- 9,999	0- 9,999	0- 4,999	0- 2,499	0- 999
02	10,000- 19,999	10,000- 19,999	5,000- 9,999	2,500- 4,999	1,000- 1,999
03	20,000- 29,999	20,000- 29,999	10,000-14,999	5,000- 9,999	2,000- 4,999
04	30,000- 39,999	30,000- 39,999	15,000-19,999	10,000-14,999	5,000- 9,999
05	40,000- 49,999	40,000- 49,999	20,000-24,999	15,000-19,999	10,000-14,999
06	50,000- 59,999	50,000- 59,999	25,000-29,999	20,000-24,999	15,000-19,999
07	60,000- 69,999	60,000- 69,999	30,000-34,999	25,000-29,999	20,000-24,999
08	70,000- 79,999	70,000- 79,999	35,000-39,999	30,000-34,999	25,000-29,999
09	80,000- 89,999	80,000- 89,999	40,000-44,999	35,000-39,999	30,000-34,999
10	90,000-104,999	90,000-104,999	45,000-54,999	40,000-49,999	35,000-44,999
11	105,000-119,999	105,000-119,999	55,000-64,999	50,000-59,999	45,000-54,999
12	120,000-134,999	120,000-134,999	65,000-74,999	60,000-69,999	55,000-64,999
13	> or = 135,000	> or = 135,000	> or = 75,000	> or = 70,000	> or = 65,000

Table C-3. Standard Sample Volume Groups and Precision Levels

For URBANIZED AREAS <200,000 Population that are NOT in NAAQS Nonattainment Areas					
AADT Volume Group	Interstate	Other Freeways and Expressways	Other Principal Arterial	Minor Arterial	Collector
	(80-10)[1] (90-5)[2]	(80-10)[1] (90-5)[2]	(80-10)[1] (90-5)[2]	Varies[3] (90-10)[2]	Varies[3] (80-10)[2]
01	0- 24,999	0- 24,999	0- 2,499	0- 2,499	0- 999
02	25,000- 49,999	25,000- 49,999	2,500- 4,999	2,500- 4,999	1,000- 1,999
03	50,000- 74,999	50,000- 74,999	5,000- 9,999	5,000- 9,999	2,000- 4,999
04	75,000- 99,999	75,000- 99,999	10,000-14,999	10,000-14,999	5,000- 9,999
05	100,000-124,999	100,000-124,999	15,000-19,999	15,000-19,999	10,000-14,999
06	125,000-149,999	125,000-149,999	20,000-24,999	20,000-24,999	15,000-24,999
07	150,000-174,999	150,000-174,999	25,000-34,999	25,000-34,999	25,000-34,999
08	175,000-199,999	175,000-199,999	35,000-44,999	35,000-44,999	35,000-44,999
09	200,000-224,999	200,000-224,999	45,000-54,999	45,000-54,999	45,000-54,999
10	225,000-249,999	225,000-249,999	55,000-69,999	55,000-69,999	55,000-69,999
11	250,000-274,999	250,000-274,999	70,000-84,999	70,000-84,999	70,000-84,999
12	275,000-299,999	275,000-299,999	85,000-99,999	85,000-99,999	85,000-99,999
13	> or = 300,000	> or = 300,000	> or = 100,000	> or = 100,000	> or = 100,000

[1] Precision levels for **individual** urbanized areas.
[2] Precision levels for **collective** urbanized areas.
[3] For **individual** urbanized areas, use (70-15) precision level for States with 3 or more individual urbanized areas. Use (80-10) precision level for States with less than 3 individual urbanized areas.

Table C-4. Standard Sample Volume Groups and Precision Levels

For URBANIZED AREAS >200,000 Population and Smaller Urbanized Areas that ARE in NAAQS Nonattainment Areas					
AADT Volume Group	Interstate	Other Freeways and Expressways	Other Principal Arterial	Minor Arterial	Collector
	(90-10)	(90-10)	(90-10)	(90-10)	(80-10)
01	0- 24,999	0- 24,999	0- 2,499	0- 2,499	0- 999
02	25,000- 49,999	25,000- 49,999	2,500- 4,999	2,500- 4,999	1,000- 1,999
03	50,000- 74,999	50,000- 74,999	5,000- 9,999	5,000- 9,999	2,000- 4,999
04	75,000- 99,999	75,000- 99,999	10,000-14,999	10,000-14,999	5,000- 9,999
05	100,000-124,999	100,000-124,999	15,000-19,999	15,000-19,999	10,000-14,999
06	125,000-149,999	125,000-149,999	20,000-24,999	20,000-24,999	15,000-24,999
07	150,000-174,999	150,000-174,999	25,000-34,999	25,000-34,999	25,000-34,999
08	175,000-199,999	175,000-199,999	35,000-44,999	35,000-44,999	35,000-44,999
09	200,000-224,999	200,000-224,999	45,000-54,999	45,000-54,999	45,000-54,999
10	225,000-249,999	225,000-249,999	55,000-69,999	55,000-69,999	55,000-69,999
11	250,000-274,999	250,000-274,999	70,000-84,999	70,000-84,999	70,000-84,999
12	275,000-299,999	275,000-299,999	85,000-99,999	85,000-99,999	85,000-99,999
13	> or = 300,000	> or = 300,000	> or = 100,000	> or = 100,000	> or = 100,000

Table C-5. Donut Area Sample Volume Groups and Precision Levels

For DONUT AREAS of NAAQS Nonattainment Areas (Small Urban and Rural Systems, Combined)		
AADT Volume Group	Minor Arterial	Major Collector, Collector
	(90-10)	(90-10)
1	0- 2,499	0- 2,499
2	2,500- 4,999	2,500- 4,999
3	5,000- 9,999	5,000- 9,999
4	10,000-14,999	10,000-14,999
5	> or = 15,000	> or = 15,000

APPENDIX D

SAMPLE SIZE ESTIMATION PROCEDURES

The sample size estimates for each stratum are derived from the following formula:

$$n = \frac{Z^2 C^2 / d^2}{1 + (1/N)\left((Z^2 C^2 / d^2) - 1\right)}$$

Where: n = Required sample size

Z = Value of the standard normal statistic for an alpha confidence level (two-sided):

Confidence Level	Value of Z	Z Squared
90 Percent	1.645	2.706
80 Percent	1.282	1.644
70 Percent	1.040	1.082

C = AADT coefficient of variation from a State's AADT data

d = Desired precision rate (from Appendix C, HPMS Field Manual)

N = Universe or population stratum size (number universe sections available for sampling in a volume group)

For example, the sample size for a stratum with a desired precision rate of ±5 percent and a 90-percent confidence level, an AADT coefficient of variation of 0.40, and 300 available universe sections for sampling, is estimated by:

$$n = \frac{(1.645)^2 (.40)^2 / (.05)^2}{1 + (1/300)\left((1.645)^2 (.40)^2 / (.05)^2) - 1\right)} = \frac{173.18}{1 + (172.18/300)} = 110 \text{ required samples}$$

If the total number of sections available for sampling (N) is not known because the State groups some or all of its nonsampled universe length, an estimate of this total may be obtained by dividing the total universe volume group length by an estimate of the average section length or the average length of the existing samples in the volume group.

The critical point in this process is the value designation of C, the AADT coefficient of variation. The original HPMS design was based on empirical estimates using data from a small number of States. The procedures presented here require the estimation of AADT coefficients of variation based on the latest State data. The results are then always up to date, based on the latest information, and are tailored to the specific State.

Estimates of the AADT coefficients of variation for a particular State can be derived from its existing HPMS data using standard statistical computer packages. The HPMS software generates the AADT coefficients of variation from a State's universe and sample data using standard statistical procedures, and produces reports that enable the State to analyze and review either the HPMS standard sample panel or the nonattainment area supplementary (donut) sample panel.

APPENDIX E

MEASURING PAVEMENT ROUGHNESS

INTRODUCTION

In order to provide a measure of pavement surface condition that has nationwide consistency and comparability and is as realistic and practical as possible, a uniform, calibrated roughness measurement for paved roadways is required by the HPMS.

Roughness is defined in accordance with ASTM E867 as "The deviation of a surface from a true planar surface with characteristic dimensions that affect vehicle dynamics and ride quality." After a detailed study of various methodologies and road profiling statistics, the International Roughness Index (IRI) was chosen as the HPMS standard reference roughness index. The summary numeric (HPMS data reporting unit) is the IRI in meters/kilometer (inches/mile). The primary advantages of the IRI are:

1. It is a time-stable, reproducible mathematical processing of the known profile.
2. It is broadly representative of the effects of roughness on vehicle response and user's perception over the range of wavelengths of interest, and is thus relevant to the definition of roughness.
3. It is a zero-origin scale consistent with the roughness definition.
4. It is compatible with profile measuring equipment available in the U.S. market.
5. It is independent of section length and amenable to simple averaging.
6. It is consistent with established international standards and able to be related to other roughness measures.

EQUIPMENT

The different methods of collecting profile and roughness data can be grouped into four classes of equipment:

Class I	Includes all manual profiling techniques such as rod and level.
Class II	Includes direct profile measuring equipment. This group also includes noncontact devices that make use of laser, infrared, or ultrasonic sensors.
Class III	Includes Response Type Road Roughness Meters (RTRRMs). The RTRRM systems measure the dynamic response of a mechanical device as it travels over the roadway surface at a constant speed. These devices use a variety of displacement technologies including the use of axle/body displacement transducers and accelerometers mounted on axles and/or bodies. Response devices must be calibrated to known profiles; they measure average rectified slope (ARS) values that can be correlated to IRI.
Class IV	Subjective estimations of roughness made by an observer using a descriptive scale that approximates the IRI for different road conditions and ride sensations.

The preferred method of obtaining IRI data for the HPMS can be found in AASHTO Provisional Standard PP37-99. This provisional standard calls for the use of a measured longitudinal profile as a basis for estimating IRI. Consequently, Class III and IV devices are unsuitable for HPMS purposes. AASHTO Provisional Standard PP37-99 is reproduced in this appendix with the written consent of AASHTO.

HPMS Roughness Measurement Procedure

Roughness is reported for HPMS in IRI units converted to either m/km or in/mi (1 m/km = 63.36 in/mi). When Class I or II equipment is used for roughness measurements, the procedure is reduced to reporting the units required by HPMS. Class III equipment (commonly referred to as an RTRRM) should not be used.

To the maximum practical extent, HPMS roughness data should be obtained from ongoing State or local Pavement Management System (PMS), Long Term Pavement Performance (LTPP) and Strategic Highway Research Program (SHRP) activities. HPMS data should be collected in accordance with AASHTO Provisional Standard PP37-99. The goal of HPMS is to ensure nationwide consistency and repeatability of roughness measurements over time and the avoidance of duplicative State data collection efforts. All equipment must be operated within manufacturer's specifications; quality assurance specifications outlined in AASHTO Provisional Standard PP37-99, Section 5, must be followed.

Each State should document and retain records of its quality assurance procedures; FHWA field offices should monitor adherence to these procedures as part of roughness data process reviews.

Roughness data should be reported in IRI units for all sections in accordance with Table IV-1 in Chapter IV. The lower functional systems (rural and urban collector and urban minor arterial) have been placed in the "recommended" category since there are situations where it may not be possible to obtain meaningful roughness measurements with profiling equipment. Major obstacles include:

- Speed restrictions
- Section lengths
- Traffic signals
- Congestion
- Pavement treatments
- Intersection treatments

However, some of these obstacles can be overcome by collecting roughness data during non-peak hours or at night, where speed, traffic, and safety are less of a problem. There are situations where it also may not be possible to obtain meaningful roughness measurements on some urban other principal arterial sections. In these cases, a value of "0" may be reported.

Verification sites require periodic remeasurement to ensure that the profile has remained stable. Heavily traveled roadways and those subjected to severe weather conditions will require remeasurement more often to reestablish the known profile. To ensure that an accurate known profile is being used for verification activities, remeasurement should be performed once per year at a minimum, just prior to data collection activities. Year-round data collection activities may require more frequent remeasurements of verification sites. Any time maintenance or resurfacing is performed on a verification section, the known profile must be reestablished.

Additional Recommendations for Collection of Roughness Data

The following field survey guidelines are recommended for State use in addition to the AASHTO Provisional Standards:

- Where roughness data are collected in both directions, the State should select one direction for each HPMS sample section to be reported and should use this same direction for that sample section in all future applications. It would be useful to choose one direction statewide, and use that for all sample sections (i.e., east to west, south to north).

- For multi-lane facilities, roughness data for the outside (right) lane should be reported. However, if this is not practical, whichever lane is measured should be used for all future HPMS reporting.
- Roughness data collection should be performed when the pavement is in stable condition. Data should not be collected during winter (frost/freeze or freeze/thaw) or wet base conditions. Data collection should be performed during good weather conditions. All manufacturer's recommended procedures should be observed. Good general practice rules include:
  - Temperature: Between 4 and 38° C (40 and 100 degrees F).
  - Wind: Data collection should not be performed when wind conditions affect the stability of the equipment/vehicle.
  - Surface: Data collection should preferably be performed when the roadway surface is dry.
- Data should only be collected at the speeds that correspond to the manufacturer's recommended speed range; speeds should also be consistent with the posted speed limit. Constant speeds should be maintained for all measurements within manufacturer's specified ranges.
- Exclude the impacts of bridge approaches and railroad crossings (or other localized discontinuities) from the roughness measurement for the roadway. Bridge decks should not be included; the objective is to obtain a measure of pavement not bridge roughness.
- Roughness measurements should be taken over a whole HPMS sample section and converted to units per kilometer (mile). However, in order to achieve equipment and speed stability, a minimum length, consistent with the manufacturer's specification, is required prior to the beginning of the measurement area. If this minimum cannot be met prior to the start of the sample section, a shorter portion of the HPMS section may be measured, but that same portion should always be measured in future roughness data collection activities. Short HPMS sections may be included in longer roughness test sections for measurement and reporting purposes. However, the same longer sections should always be measured in future data collections.

COORDINATION WITH OTHER ACTIVITIES

One of the goals of HPMS is to avoid duplicate data collection efforts. States are encouraged to coordinate roughness measuring activities, where possible, such that the same equipment, verification sites, and measurements are used for multiple purposes. Therefore, HPMS activities should be coordinated with other State activities such as the Strategic Highway Research Program/Long Term Pavement Performance and the State Pavement Management Systems.

The LTPP activities monitor pavement performance and use in detail for approximately 1,500 pavement sections nationwide as part of SHRP. Attempts should be made to ensure that as many LTPP sections as possible are also HPMS standard sample sections or at least representative (i.e., in close proximity) of HPMS samples. The pavement and traffic monitoring data collected on LTPP sections should be used for the HPMS universe or standard sample sections, where possible.

Efforts should be made to utilize the LTPP established sections/profiles as multiple use verification sections in each State.

Many State and some local transportation agencies have operational or are developing a PMS to guide program development, improve life-cycle costs, and help select the most effective pavement improvement strategies. The HPMS pavement data reporting should make full use of existing PMS data and collection activities.

STANDARD PRACTICE FOR DETERMINING ROUGHNESS OF PAVEMENTS

AASHTO DESIGNATION: PP37-99[1]

1. Scope

1.1 This practice describes a method for estimating roughness for a pavement section. An International Roughness Index (IRI) statistic is calculated from a single longitudinal profile measured with a road profiler in both the inside and outside wheelpaths of the pavement. The average of these two IRI statistics are reported as the roughness of the pavement section.

1.2 The practice recognizes the need for a quality assurance (QA) plan and proposes guidelines for the development of a QA plan.

1.3 Measurements of profile are made in accordance with ASTM Designation E 950, "Test for Measuring the Longitudinal Profile of Vehicular Traveled Surfaces with an Inertial Profilometer." If this practice is at anytime in conflict with references made, such as ASTM Standards, this practice takes precedence for its purpose.

1.4 *This practice does not purport to address all of the safety issues, if any, associated with its use. It is the responsibility of the user of this practice to establish appropriate safety and health practices and determine the applicability of regulatory limitations related to and prior to its use.*

2. Reference Documents

2.1 ASTM Standards

E1166	Guide for Network Level Pavement Management.
E867	Terminology Relating to Traveled Surface Characteristics.
E950	Test for Measuring the Longitudinal Profile of Vehicular Traveled Surfaces with an Inertial Profilometer.

2.2 Other References

2.2.1 Sayers, Michael W., "On the Calculation of IRI from Longitudinal Road Profile," the University of Michigan, Transportation Research Institute, Preprint TRB, 74th Annual Meeting, Washington, D.C., January 1995.

2.2.2 Sayers, Michael W., T. D. Gillespie, and W.D.O. Paterson, "Guidelines for Conducting and Calibrating Road Roughness Measurements," The World Bank Technical Paper Number 46, The World Bank, 1986.

3. Significance and Use

3.1 This practice outlines standard procedures for measuring longitudinal profile and calculating the International Roughness Index (IRI) for highway pavement surfaces to help produce consistent estimations of IRI for network level pavement management.

4. Terminology

4.1 Definitions

4.1.1 Roughness - According to ASTM E867, roughness on a traveled surface is defined as the deviation of a surface from a true planar surface with characteristic dimensions that affect vehicle dynamics and ride quality.

In this practice, the term roughness is the average of two IRI statistics calculated from longitudinal profile measurements, one in each pavement wheelpath.

[1] This standard is based on SHRP Product P338

4.1.2 Longitudinal Profile - A longitudinal profile is the set of perpendicular deviations of the pavement surface from an established horizontal reference plane to the lane direction.

4.1.3 International Roughness Index (IRI) - The IRI is a statistic used to estimate the amount of roughness in a measured longitudinal profile. The IRI is computed from a single longitudinal profile using a quarter-car simulation as described in the report, "On the Calculation of IRI from Longitudinal Road Profile." [Sayers 95] A FORTRAN program is provided in Appendix X1 of this procedure to calculate the IRI statistic from a longitudinal profile.

5. Quality Assurance

5.1 Agencies using this practice are required to develop a satisfactory quality assurance plan. At a minimum, the plan shall include the requirements listed in the following sections.

5.1.1 Certification and training record of individuals conducting the survey.

5.1.2 Accuracy and calibration records of equipment used in the survey.

5.1.3 Periodic and ongoing quality control program and the content of the program.

> Note 1 - The estimate of roughness of pavements can be used both at network and project level pavement management. Guidelines for network level are included in ASTM E1166, which can be used as a source for the development of a QA plan.

> Note 2 - The guidelines that can be used for the development of a quality assurance program are given in Appendix X2.

6. Recording of Data

6.1 Agencies using this practice are expected to designate the lane(s), direction(s) of travel to be surveyed based on sound engineering principles, and management needs within the agency.

6.2 Locate (place) the two sensors, separated approximately 1.6 to 1.8 meters (63" to 71") in the wheelpaths. The longitudinal profile points used for calculating the IRI shall have a longitudinal spacing not greater than 150 mm (5.9"). Long wavelength filters are used to remove all wavelengths exceeding 60 m (197').

> Note 3 - The use of anti-aliasing filters and averaging to remove small wavelength content from the profile is left to the agency and equipment manufacturers.

7. Calculations

7.1 Calculate IRI values for each 0.1 km (0.62 mi) for both wheelpaths. Compute an average of the two IRI values to determine roughness.

> Note 4 - The tenth of a kilometer values are needed to calculate average values for each data collection section.

8. Report

8.1 Report IRI to the nearest one-tenth meter per kilometer (0.1 m/km), no English units are applicable. This does not preclude more accurate recording of the IRI.

8.2 Report the roughness calculated in Section 7.1 to the nearest one-tenth meter per kilometer (0.1m/km).

8.3 Use the length of the data summary interval of 0.1 km (0.062 mi.).

8.4 The minimum data recorded and stored for each section shall include:

8.4.1 Section Identification - List all available information necessary to locate the section using agency's current referencing system.

8.4.2 IRI for each of the two wheelpaths. (m/km).

8.4.3 <u>Average</u> of both IRI's calculated for the section. (m/km).

8.4.4 Date of data collection. (month/day/year).

8.4.5 Length of section in meters for which the data is collected.

8.4.6 Profile sampling interval.

8.4.7 Long wave length filter setting.

8.4.8 Pavement surface temperature.

APPENDIX X1

FORTRAN Program to Calculate IRI from Profile

(Nonmandatory Information)

[FHWA Note: For discussion of IRI, including Fortran and RoadRuf programs, go to Internet website: http://www.umtri.umich.edu/erd/roughness/iri.html.]

The Fortran program was developed by Sayers in 1995 at the University of Michigan. [Sayers 95] and complies with requirements of PP37.

Note 1 - Practice requires IRI to be reported in units of meters per kilometer (m/km), the profile elevations (Variable PROF in subroutine IRI) are measured in millimeters, and input distance between elevation points (variable dx in subroutine IRI) is measured in meters. Consequently, the UNITSC value in the program should be set to one (1.0).

Note 2 - Another software program is available from the University of Michigan Transportation Research Institute (UMTRI), named RoadRuf. This Microsoft Windows C based software contains procedures for calculating IRI and many other profile analysis capabilities. The software can be made to comply with the requirements of this protocol. It is public domain and can be downloaded from the Internet at http://www.umtri.umich.edu. Setup options are discussed in the accompanying documentation.

APPENDIX X2

Guidelines - Quality Assurance Plan

(Nonmandatory information)

X2.1 Quality Assurance Plan - Each agency shall develop a quality assurance plan. The plan shall include survey personnel certification training records, accuracy of equipment, daily quality control procedures, and periodic and on-going quality control. The following guidelines can be used for developing such a plan.

X2.2 Certification and Training - Agencies are individually responsible for training and/or certifying their data collection personnel and contractors for proficiency in using the profile measuring equipment according to this practice and other applicable agency procedures.

X2.3 Equipment Calibration - Equipment Calibration (accelerometers and non-contact sensors) is done in accordance with specific manufacturer recommendations. The equipment must operate within the manufacturer's specifications. A regular maintenance and testing program is established for the equipment in accordance with the manufacturer's recommendations.

X2.4 Verifications Sections - Verifications sections are selected with known IRI statistic for both wheelpaths. These sections are measured by equipment operators on a regular basis. Evaluations of these measurements can provide information about the accuracy of field measurements and give insight into needed equipment calibration. Verification sections are rotated on a regular basis in order to assure that the operators are not repeating previously known IRI statistics during the verification. An alternate to verification sections might be to remeasure and compare up to 5% of the data as a daily or weekly quality check.

X2.5 Quality Checks - Additional quality checks can be made by comparing last year's IRI statistics with current measurements. At locations where large changes occur, the pavement manager may require additional checks of the data.

APPENDIX F

TRAFFIC MONITORING PROCEDURES FOR THE HPMS

INTRODUCTION

High quality traffic data are critical to the many uses of the HPMS data set:

- Traffic derived travel data from the HPMS are used in the Federal-aid Highway fund apportionment formulae;
- Traffic data are critical to the analyses that support the Condition and Performance Reports to Congress which are subsequently used for national highway budgeting purposes;
- HPMS derived travel data are required to meet Clean Air Act requirements; and
- Travel data are central to estimating several of the Department's performance indicators such as vehicle crash and fatality rates and delay.

Traffic monitoring is also a key activity in the development and maintenance of the HPMS data set. Traffic data drives the HPMS sample stratification and selection process; the validity of the entire HPMS sample expansion procedure depends on the maintenance of adequate traffic monitoring programs.

GENERAL

State maintenance of an adequate traffic counting program is a primary HPMS concern. A State's count program should cover all Interstate, principal arterial, other NHS, and HPMS sample sections on a 3-year maximum cycle. It should cover all roads, not just State-owned roads, and should include counts on those systems made on the State's behalf by MPOs, cities, or counties. The program should provide for a sufficient number of automatic traffic recorder (ATR) stations and classification count stations to permit factoring of 48-hour tube-type counts to estimates of annual average daily traffic (AADT). The State should also have an underlying short count program that assures that traffic counts on all roads on all systems are obtained over a longer term (6-year maximum) cycle for basic traffic monitoring purposes. For further details, see the discussion of Data Obsolesce Counts in Chapter 2 of the *AASHTO Guidelines for Traffic Data Programs*. The information provided by the State's overall count program should be of sufficient detail to permit the State to develop and maintain comprehensive traffic flow maps in rural and urban/urbanized areas.

Traffic information in a comprehensive count program may be available from several monitoring sources including State, MPO, city, or county. Automatic traffic recorders provide continuous monitoring of existing traffic conditions around the State. Vehicles on freeways/expressways and other important multi-lane facilities can be monitored by route under a multi-year statewide or MPO count plan that includes input from real-time intelligent transportation system (ITS) deployments. Other highway functional systems, both State and off-State, can be monitored by geographic area, such as by county or highway district.

A schedule should be developed for the State's comprehensive count program. Areas of the State selected for counting in a program year should be selected on a random basis. Areas of high growth should be counted more often than those with low growth; although all areas should be comprehensively counted at least every 6 years. To make the most of available resources, an area traffic count plan should consider using cluster count techniques. Counts scheduled and obtained under other programs should be incorporated into the count plan to avoid duplication of monitoring sites. Coordination and cooperation with local governments to implement a shared data, comprehensive count program is highly desirable; however, the State ultimately maintains responsibility for ensuring that these data meet minimum collection and quality requirements. To meet these responsibilities, the State should have a comprehensive quality assurance program that includes data collection, the conversion of traffic counts into AADT values, and equipment testing provisions.

Information collected from all monitoring programs should be maintained in a computerized database, preferably in a geographic information system. If several years of data are maintained, traffic growth by location will be more readily available for developing trends, determining changes to volume group breakpoints, scheduling of future monitoring, and other uses. Note that although some planning and design activities, such as urban planning models, may make use of average weekday traffic (AWT) estimates, the HPMS makes use of AADT estimates.

VOLUME GROUP ASSIGNMENTS

The State's comprehensive traffic count program can be used to develop traffic volume group assignments for all road sections if the program has been formulated to adequately monitor both high and low volume roads, including those off the State system. To facilitate this process, count station locations should be selected to represent expected AADT volume group breakpoints for the volume ranges of both the standard and nonattainment area samples. This may require locating count stations at one per 5 to 10 miles in rural areas and more closely in urban areas; for homogeneous traffic sections, more than one section may be represented by a single traffic count station. Selection of count station locations should be based on previous count experience, recent land developments, and the existence of uncounted sections along the routes.

Generally, traffic counts in addition to those taken for the HPMS are needed to establish the assignment of road sections to their respective volume groups in both rural and urban areas. A well-designed comprehensive count program that includes off-State system roads should provide the needed additional counts. Traffic mapping techniques also can be applied to maximize the use of HPMS universe and sample counts, other coverage counts, and counts taken for project planning or operational purposes in assigning road sections to volume groups.

TRAFFIC MONITORING GUIDE

A detailed discussion of recommended procedures for developing reliable estimates of travel characteristics, including AADT, is contained in the *Traffic Monitoring Guide* (TMG). However, a general discussion of some elements of a typical traffic volume count program and their applicability to the HPMS follow.

Continuous ATRs

Automatic Traffic Recorders (ATRs) are used to provide continuous traffic count coverage at selected locations. ATR data are also used to develop seasonal or monthly, day-of-week, and growth factors which are then used to adjust short coverage counts to AADT. Analytical procedures to determine the appropriate level of effort and to develop the needed traffic estimates are described in the TMG.

Continuous count data are essential for converting coverage counts to AADT. The State's documentation of its continuous count program should discretely identify the number of continuous counters on the rural and urban portions of the PAS/NHS system. Whenever possible, the State should have at least one continuous counter on each major PAS/NHS highway route. At a minimum, each continuous counter should have at least two full days of data for each day of the week for each month.

Short Counts

Although short counts can cover lesser periods, the TMG recommends using 48-hour counts (two full 24-hour days) for all HPMS universe, standard sample, and donut area sample sections whether on or off the State-owned highway system. Short counts should be randomly scheduled geographically throughout the State and temporally throughout the calendar year to ensure adequate representation and to minimize bias. Where axle correction factors are needed to adjust raw counts, they should be derived from facility specific vehicle classification data obtained on the same route or on a similar route with similar traffic in the same area. Factors that purport to account for suspected machine error in high traffic volume situations should not be applied to HPMS traffic counts or traffic count programs used for HPMS purposes, such as volume group assignment. In high volume situations, such as controlled access facilities, it is more appropriate to use ramp counts in conjunction with strategic mainline counting, or other appropriate technology, than to use short counts and adjustment factors.

Vehicle Classification Data Collection

Data reported in the HPMS should reflect the use of statistically valid data collection procedures employing automatic vehicle classification equipment. Summary vehicle classification data reporting requirements are outlined in Chapter III; percent trucks data are reported in Items 81-84 for each HPMS standard sample section (see Chapter IV). Axle corrections based on vehicle classification data should be applied to all counts where the counting device uses axle sensors. State documentation of the vehicle classification activity should illustrate that:

a. Classification data are representative of specific functional systems.
b. Each season of the year is represented in the development of axle correction factors.
c. Classification sessions are long enough to account for the changes in vehicle mix from day to day. The TMG recommends that vehicle classification sessions be at least 48-hours. Data for less than 24 continuous hours is not appropriate.
d. The total volume of vehicles observed is at least equal to that for an average day.
e. Classification counts are well distributed among rural and urban locations.
f. Classification counts are collected, at a minimum, over a 3-year cycle, one-third of the counts per year.
g. There are sufficient classification categories to represent vehicles with two to seven axles.

APPLICATION OF TRAFFIC COUNT PROCEDURES TO HPMS

Traffic count data reported for all Interstate, other principal arterial, and other NHS sections provide most of the travel data used for apportionment and other purposes (see Chapter 1, Table I-2). The HPMS standard sample design provides an appropriate statistical base for the development of traffic estimates for each sampled section and of systemwide travel for the sampled systems. By incorporating vehicle classification and truck weight information, the TMG structure provides the capability of estimating classified VMT and Equivalent Single Axle Loads (ESALs) from the HPMS data.

One-third of the Interstate, other principal arterial, and NHS road sections should be counted each year. In addition, one-third of the HPMS standard sample sections on each functional system should be counted each year. The sections to be counted should be randomly selected. Samples should be selected from each sample stratum (volume group), although minor adjustments may be necessary for strata with numbers of sections not divisible by three or having less than three samples. A single count may be used for several sections between adjacent interchanges on controlled access facilities.

The development of section AADT estimates from count data must include the use of short count and other appropriate adjustment factors. AADTs reported to the HPMS for standard sample and non-sample PAS/NHS sections not counted during the current year must be updated to current AADT estimates by use of appropriate growth factors.

Estimates of Daily Vehicle-Miles of Travel (DVMT) can be developed by direct computation for the Interstate, other principal arterials, and other NHS sections and by expansion of the HPMS standard sample on a functional system basis for other systems. This is done by multiplying the standard sample section AADT by the section length and by the standard sample expansion factor and summing the result to the HPMS stratification level desired (functional system, total rural, etc.); the HPMS software will perform these calculations by functional system. Since HPMS standard sample expansion procedures are based on the ratio of universe to sample mileage, mileage totals at any stratification level should be exact. A comprehensive count program, good count practices, a well-distributed HPMS standard sample, and appropriate AADT estimation techniques will result in highly reliable DVMT estimates.

The same procedures can be used in preparing and reporting count based AADT data for donut area sample sections; a unique expansion factor for each applicable NAAQS nonattainment area is used to prepare DVMT estimates.

APPENDIX G

REPORTING TRAVEL DATA IN AIR QUALITY NONATTAINMENT AREAS

INTRODUCTION

The HPMS is a consistent, efficient mechanism through which travel tracking information can be developed. To minimize burden and avoid duplication of efforts by States, MPOs, and local governments for travel monitoring and data reporting, EPA has chosen to rely on the HPMS as the principal tool for meeting the Environmental Protection Agency's (EPA's) travel monitoring needs.

The requirements for travel estimates for National Ambient Air Quality Standards (NAAQS) nonattainment areas as designated by EPA were developed in response to the Clean Air Act Amendments (CAAA) of 1990. Specific EPA travel monitoring requirements for designated NAAQS nonattainment areas can be found in Section 187, Vehicle Travel Forecasting and Tracking Guidance (*Federal Register*, March 19, 1992, Volume 57, No. 54). This guidance calls for States/MPOs having affected urbanized nonattainment areas to estimate total annual vehicular highway travel using HPMS procedures.

HPMS data are also used in establishing regional transportation-related emissions for transportation conformity purposes in accordance with the Transportation Conformity Rule, 40 CFR parts 51 and 93. Estimated vehicle-miles of travel (VMT) based on the HPMS are used for calibration and validation of base-year network-based travel models when required in nonattainment or maintenance areas.

For conformity purposes, locally developed county-based programs and other procedures different from the HPMS procedures are permitted subject to interagency consultation procedures. See 40 CFR Parts 51 and 93, Transportation Conformity Rule Amendments: Flexibility and Streamlining (*Federal Register*, August 15, 1997, Volume 62, N. 158) for further details. In general, it is the State's responsibility to negotiate specific departures from use of the HPMS to track travel change with EPA and FHWA field offices through the interagency consultation procedures cited above. Where HPMS is used for travel tracking purposes, States should establish the following in cooperation with EPA and FHWA field offices:

- The specific areas for which travel data will be required.
- The type of nonattainment area pollutants that require travel information.
- The severity classifications for which travel data will be required.

To meet the Clean Air Act requirements, travel data are to represent total travel within the NAAQS nonattainment area boundary surrounding affected urbanized areas. The design of the HPMS permits its use for these purposes only in those NAAQS nonattainment areas that contain one or more complete urbanized area(s). The HPMS sample is not valid if an urbanized area is split by a nonattainment area boundary or if parts of an urbanized area are included in multiple nonattainment areas. Within any nonattainment area boundary, the land area outside of the FHWA-approved adjusted urbanized area boundaries classified as rural or small urban (places between 5,000 to 49,999 population) is referred to as the donut area.

Travel estimates within NAAQS nonattainment areas are derived using HPMS procedures for higher functional systems. However, it is important to note that procedures for estimating travel on the rural minor collector and local functional systems, while important for tracking nonattainment area travel, are not specified in the Manual or by FHWA. Travel on these lower systems is developed using State and local methods and procedures and reported to the HPMS as summary data (see Chapter III).

NAAQS NONATTAINMENT AREA CODES

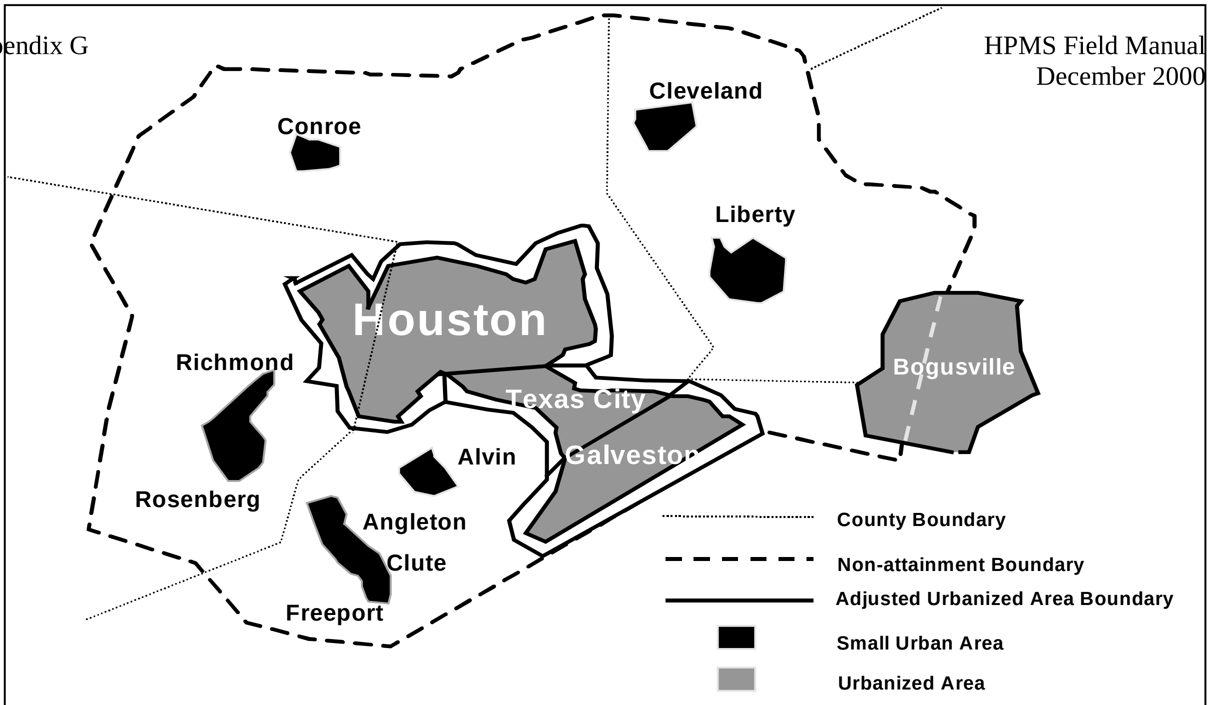
The three-digit urbanized area codes shown in Appendix B are used for nonattainment area coding in HPMS. Assign NAAQS nonattainment area codes (Item 16) following these general rules:

- If a named NAAQS nonattainment area includes only one urbanized area, the nonattainment area code is the same as the urbanized area code;
- If a named NAAQS nonattainment area includes more than one urbanized area, the nonattainment area code used for each urbanized area within the named NAAQS nonattainment area is that of the primary urbanized area;
- For rural and small urban areas outside the boundaries of the FHWA-approved adjusted urbanized area(s) but within a named NAAQS nonattainment area, the nonattainment area code is that of the primary urbanized area.

Use this coding consistently for summary data as well as for universe, standard sample, and supplementary sample sections. When the primary urbanized area in a nonattainment area is in another State, the assigned NAAQS nonattainment code must be for the primary urbanized area in the adjoining State.

An NAAQS nonattainment area is illustrated for “Houston” in Figure G-1. It consists of the urbanized areas of Houston (the primary urbanized area), Texas City, Galveston, six small urban areas and the remaining rural area. All of the data for the urbanized areas, small urban areas, and rural areas within the NAAQS nonattainment area must be coded with the FHWA urbanized area code of Houston (015) as the nonattainment area code. The table below contains the proper coding for a universe, standard sample, or supplementary sample section and for required summary data fields. A fictitious urbanized area (Bogusville) is shown in Figure G-1, straddling the Houston nonattainment area boundary. As previously noted, HPMS cannot be used to produce travel estimates for split urbanized areas. The nonattainment area code for this area should be coded “000”; any air quality travel estimates for Bogusville must be done outside of HPMS.

Houston NAAQS Nonattainment Area		
Urbanized Area Code	**Nonattainment Area Code**	**Location**
015	015	Houston Urbanized Area
137	015	Galveston Urbanized Area
250	015	Texas City Urbanized Area
999	000	Bogusville
000	015	Small Urban Area
000	015	Rural Area



Urbanized Area Code	Non-attainment Area Code	Location
015	015	Houston Urbanized Area
137	015	Galveston Urbanized Area
250	015	Texas City Urbanized Area
000	015	All Small Urban Areas
000	015	All Rural Area
999	000	Bogusville

Figure G-1. Houston NAAQS Nonattainment Area

For all road segments outside of nonattainment areas, code “000” in the nonattainment area data item.

DONUT AREA SAMPLING PROCEDURES

GENERAL

The following discussion outlines procedures for developing a sample panel of highway sections that can be used to estimate travel for certain functional systems in the donut area of an NAAQS nonattainment area. The donut area sample panel is a combination of existing standard sample sections and randomly selected supplementary sample sections in the donut area.

Donut area sample procedures use:

- the same methodology for selecting the standard sample panel (Chapter VII),
- the HPMS standard stratification levels, and
- established HPMS sampling procedures.

These procedures require that all urban and NAAQS nonattainment area boundaries be clearly established based on the latest FHWA-approved, adjusted urban area boundaries and agreed-upon nonattainment area boundaries. They also require an up-to-date functional classification of all roadways within the donut area. Finally, these procedures also depend on the existence of accurate length and road section information within the donut area boundary. The donut area sampling procedures apply only to roads functionally classified as rural and small urban minor arterial, rural major collector, and small urban collector within the donut area boundary.

DONUT AREA BOUNDARY

The development of the donut area sample depends on established, up-to-date, and recognizable boundaries. The FHWA approved, adjusted urban area boundaries and the NAAQS nonattainment area boundaries of each donut area should be available on State or MPO maps. The adjusted boundaries of urbanized and small urban areas in the nonattainment area must be based on the latest Decennial Census.

STANDARD SAMPLE REVIEW

The donut area sample panel is comprised of:

- Existing standard sample sections in the donut area; and,
- Supplementary sample sections if needed to achieve the required travel estimate precision in the donut area.

The first step in designing a donut area sample panel is to optimize the standard sample panel using the HPMS sample adequacy software and the procedures described in Chapter VII and Appendices C and D. The donut area sampling methodology requires an up-to-date and error-free standard sample panel without boundary, volume group, or universe definition problems; the existing standard sample panel must also meet the established HPMS precision criteria. Proceeding to develop a donut area sample panel without a clean standard sample panel and a well-defined universe will result in inaccurate information.

DONUT AREA SAMPLING UNIVERSE

The universe to be sampled consists of all highway sections within State boundaries that are functionally classified as rural minor arterial, rural major collector, small urban minor arterial, and small urban collector. In addition, they are located within the defined nonattainment boundary and are outside of all urbanized area boundaries.

In cases where donut areas cross State lines, all State portions must be sampled. The involved States should coordinate the sample size calculation using the whole donut area universe (all States combined), and then sample a minimum of each State's pro rata share of the required samples based on the existing universe length in each State for each donut functional system and volume group stratum. Expansion factors are developed based on the universe and sampled length within each individual State.

DONUT AREA UNIVERSE STRATIFICATION

The functional system strata are designed to maintain consistency with the standard sample, but combine rural and small urban sections for sampling efficiency. The donut area universe is stratified into two donut functional systems (donut minor arterial and donut collector) and five volume group stratifications.

This results in 10 possible donut panel strata (two donut functional systems and five volume groups).

The donut minor arterial system consists of both the small urban and rural minor arterial systems. The donut collector system consists of the rural major collector and the small urban collector systems. The volume group strata have been defined to minimize the number of strata and help reduce the overall sample size. The volume group categories are as follows:

Volume Group	AADT
1	1 to 2,499
2	2,500 to 4,999
3	5,000 to 9,999
4	10,000 to 14,999
5	15,000 or higher

These volume groups should be representative of minor arterial and collector sections in most donut areas. In larger nonattainment areas, Volume Group 5 may include a greater volume range than the lower volume groups. This will not pose a problem if the functional class definition used by the State conforms with the standard definition; where it does not, or where other special circumstances exist, the volume groups may be expanded or changed. If other volume groups are selected, the AADT limits of the volume groups must be reported to FHWA with the HPMS submittal.

PREPARING THE DONUT AREA UNIVERSE SAMPLING FRAME

A universe sampling frame is a listing or file of all the sections from which a sample panel is selected. A complete inventory must be undertaken to determine the length of roadway in each stratum and to identify the universe sampling frame elements (sections). To create the sampling frame, all donut area roadways in the two donut area functional systems must be broken down into road sections by the five volume groups; samples will be selected from these strata. The information needed for each road section includes:

- nonattainment area code
- inventory route number
- functional system code
- AADT estimate
- donut area sample panel volume group
- length of section
- beginning and ending section kilometerpoints (milepoints) [or other termini point definition]

Since the donut area sample is used for estimating travel, each universe sampling frame section should be as homogenous as possible with respect to AADT. In theory, each AADT change necessitates the creation of a new road section. In practice, a new road section should be created when the AADT changes by 10 percent or more. Road sections may correspond to major intersections or access points where AADT changes are estimated to exceed 10 percent of the traffic. Knowledge of the road system, and exercise of engineering judgment, may be necessary in some situations. Donut area samples may be split to maintain traffic homogeneity. However, the need to split samples in the future can be minimized by keeping the original donut universe sampling frame sections relatively short in length.

Existing universe sections in donut areas may be used as a sampling frame. However, since they may have been defined according to different criteria, a thorough examination is required to ensure that the section breaks are at reasonable positions along the roadway and appropriately reflect AADT change points.

PRECISION LEVEL SPECIFICATION

The objective of the HPMS is to achieve estimates of travel within the donut areas at a 90-10 confidence (precision) level. Most of the total travel for the donut area is developed from the principal arterial universe data (which has no sampling error). The precision of the donut area sample is set at 90-10 to ensure that the travel developed from the expanded sample will meet this objective. While travel for the lower level systems (local and minor collector) is determined from procedures external to the HPMS and has an unknown precision level, it represents very little of the total travel in the donut area.

DONUT AREA SAMPLE SELECTION PROCESS

GENERAL

The donut area sample selection process consists of:

- Determining the AADT variability (coefficient of variation) of the universe sampling frame sections,
- Applying the sample size equations (Appendix D),
- Determining how many sections from the standard sample are available,
- Randomly selecting supplementary sample sections,
- Examining the sample for representation validity, and
- Computing the expansion factors.

Each of these steps is discussed in detail in the following paragraphs.

DETERMINING STRATUM VARIABILITY

The determination of sample size is dependent on the variability of the characteristic to be measured – AADT, in this case. The basic purpose of the sample is to estimate travel and the only characteristic available to estimate sampling frame variability is AADT. Variability is estimated by computing the coefficient of variation (C.V.) of AADT. The C.V. is the ratio of the standard deviation to the mean.

A preliminary estimate of the C.V. for the established traffic volume groups can be determined by estimating the standard deviation as one-sixth of the range, and the mean as the midpoint of the range. For example, for Volume Group 1, the standard deviation is estimated at 417 (dividing the range 2,500 by 6), the mean is estimated at 1,250 (the midpoint of the range between 1 and 2,499), and the C.V. is .33 (417/1,250). C.V. estimates from this procedure assume a normal distribution throughout the range, which is not likely to be the case for traffic volumes. If, for example, the mean were 1,000 rather than 1,250, the C.V. estimate would be .42. Since sample size is directly related to the C.V., the use of these conservative values help to ensure achievement of the desired precision.

Assuming that the AADT values assigned to each section are fairly accurate, estimates of the C.V., the standard deviation, and the mean are common values that can be computed directly from the sampling frame using HPMS software or other spreadsheet, database or statistical packages.

DETERMINING STRATUM SAMPLE SIZE

The procedures and equations for determining stratum sample size are included in Appendix D. The values to be used for the donut area sample size calculation are:

Z = 1.645 (for 90-percent confidence)
d = .10 (for the desired precision rate of 10 percent)
N = the number of universe sections available in the donut area sample stratum
C = the C.V. calculated as stated above for the donut area sample stratum

A sample size calculation must be done for each donut panel stratum that contains universe sections. The minimum number of samples in each stratum is three; if less than three sections exist in a stratum, sample all.

Once a sample size is determined for each stratum, all standard sample sections for the donut functional systems are reviewed to determine how many fall within the specific donut area. A map of the donut area marked with the location of existing standard sample sections may be useful in making this review. The number of supplementary samples required is the difference between the stratum sample size computed in the previous step and the number of standard samples available. For example, if the computed sample size in the first donut area stratum is 50 and 30 standard samples are available, then 20 supplementary samples are needed.

RANDOM SAMPLE SELECTION PROCESS

The standard sample sections should be eliminated from each universe sampling frame stratum prior to selecting the supplementary sample. This will require identifying the standard samples, establishing the termini points of each section, and appropriately reducing the universe sampling frame stratum size. The existing standard sample stratum sections will reduce an equal number of universe sampling frame stratum sections. For example, if 30 standard sample sections are available in a stratum and 500 sections existed in the universe sampling frame for the same stratum, the modified universe sampling frame stratum will consist of 470 sections.

The supplementary sample is selected using simple random sampling procedures. The selection procedure can be applied after the modified universe sampling frame stratum is prepared by using computerized selection techniques available with most statistical packages or by using the manual method described below.

Manual method: After removal of the standard sample sections, all road sections remaining in the universe sampling frame stratum are assigned a unique, sequential number beginning with the number 1. If the universe sampling frame for a particular stratum has 500 remaining sections, for example, then numbers 1 through 500 are assigned to the sections available for sampling.

At this point, use a table of random numbers to select the supplementary sample from the universe sampling frame; discard duplicate or missing random numbers or random numbers out of the universe sampling frame stratum range. Repeat this step until the number of required supplementary samples plus the number of existing standard samples is at least equal to the required sample size for each stratum.

JUDGING THE VALIDITY OF THE SAMPLE

The manner in which the donut area sample panel is selected does not follow a strictly theoretical random sampling application. A random standard sample from one sampling frame has been combined with a random supplementary sample from another. When the donut sample is larger than the existing standard sample and the supplementary sample has been picked randomly, the result will likely be a fairly representative sample panel. However, when the supplementary sample is small or nonexistent due to the availability of many standard samples, the resulting combined sample may not be statistically representative of the donut area. This is more likely to occur in large donut areas covering several small urban areas or large rural areas, and may result in biased estimates of travel.

As a validity check, the standard and supplementary sample section locations should be reviewed on a map of the donut area. If the combined donut area sample is not well dispersed over the geography and routes of the donut area, or if sampled sections are concentrated in one part of the area such as in the small urban areas or in one sector of the donut area, then the sample panel may not be representative.

A determination of the validity of the donut area sample panel must be made; if the donut area sample is not representative, then steps should be taken to reselect supplementary samples or increase the sample size.

COMPUTATION OF DONUT EXPANSION FACTORS

The donut area sample panel uses its own volume groups and expansion factors to produce the desired travel estimates. The HPMS sample methodology expands the sample based on the ratio of universe length to sample length for each sample stratum. This process results in a single computation for each stratum and allows simple checking since expansion factors are unique for each stratum. For example, if the stratum universe length is 250 and the stratum sample length is 50, the donut area expansion factor for the stratum is 5 (250/50). This expansion procedure provides a clear length check; when the sample length is computed and expanded, it must equal the universe length for the stratum. The sum of the expanded lengths for each volume group in the donut minor arterial and collector systems must equal the total universe length for the donut functional systems.

The HPMS donut area sample section that is also a standard sample section has two expansion factors. The standard sample expansion factor is used to expand data in the standard sample; the donut area expansion factor is used to expand the sample section AADT to an estimate of travel for the donut functional system.

ESTIMATING TOTAL TRAVEL IN THE DONUT AREA

Travel estimates within the NAAQS donut area are derived from universe data for the principal arterial functional system; from the combined donut area sample for the rural minor arterial, small urban area minor arterial, rural major collector, and small urban area collector systems; and from State/local summary travel estimates for the small urban and rural local systems and the rural minor collector system.

The travel estimate from universe data is simply computed by multiplying the AADT times the section length for each section and summing the results for all sections. Travel estimates from summary data are used as provided by the States for the rural minor collector and the small urban and rural local systems. The travel estimate from the donut area sampled systems is computed by multiplying the AADT by the section length and by the donut area expansion factor for each sample section and summing these values for all donut area sample sections. The sum of these three estimates is the travel estimate for the donut area portion of the NAAQS nonattainment area.

To obtain the total travel estimate for the NAAQS nonattainment area, the urbanized area travel total for the urbanized area(s) contained within the NAAQS nonattainment area must be added to the total donut area estimate to obtain the areawide NAAQS nonattainment area travel total.

If the required travel estimate is to be stated as an annual (rather than daily) value, the daily result acquired above is to be multiplied by 365 (366 in leap years).

MAINTAINING THE SAMPLE

The universe sampling frame sections and length and sample stratum makeup will change over time and begin to invalidate the sample panel as a result of travel growth, development within the donut area, etc. Several sample maintenance steps are advised:

- A sample panel reevaluation should be carried out every 3 years, at a minimum, to ensure that the sample panel remains representative of the universe in the donut area;
- If universe sections or donut area samples have a change in AADT that causes a shift of sections from one volume group to another, recalculate the expansion factors for the next HPMS submittal;
- AADT on the universe sampling frame sections needs to be monitored to ensure that sections are maintained in the proper stratum. If the universe length is not correctly stratified, the expansion factors will not be correct and the resulting travel estimates will be biased;
- An expansion factor maximum of 99.999 should be maintained; additional samples should be chosen as necessary to keep the expansion factor below this maximum;
- A minimum of three samples per stratum must be maintained.

APPENDIX H

LRS DATA FILE TEMPLATE PROCEDURES

The data required for the Linear Referencing System (LRS) templates are described in Chapter V. This chapter provides assistance to the user for entering the Node Data File and the Inventory Route Link Data File in dBase III or IV. This information can also be provided as an ASCII file on floppy disk, CD, or as an electronic file. For a more complete discussion of the data transfer media and necessary documentation, please see Chapter V.

GENERAL GUIDELINES

The following discussion assumes the user is familiar with dBase and that the appropriate version of dBase is available. A dBase template is provided for both the Node Data File and the Inventory Route Link Data File information listed in Chapter V. These are named NODE.DBF and LINK.DBF, which must be added to one of the user's dBase catalogs. This is accomplished by copying these files into the dBase working directory. At the dBase dot prompt, type:

.USE <NODE or LINK>

Where NODE and LINK are the NODE.DBF and LINK.DBF files described above.

SPECIFIC OPTIONS

OPTION 1: Manual Data Entry, Abbreviated Field Names

- Once the "USE" command has been executed for either the NODE or LINK files, the user can begin to enter data for that file. This is done by using the "APPEND" command:

  .APPEND

  The template will appear in the upper left corner of the computer screen and is ready for data entry.

- Add data to the file by typing in the appropriate codes or values.
  - Single records are presented on the screen with fields placed in a vertical structure for each record in the same order as shown in Chapter V (i.e., Year is above State Code, which is above County Code, etc.).
  - The cursor will move from one field to the next as data is entered (when the "Enter/Return" key is depressed). dBase will not allow the user to enter character data into a numeric field.
  - Once a record is complete (when "Enter/Return" is depressed at the last data item), a new record will appear. This will continue until the operator discontinues the data entry process and saves the data file.

OPTION 2: Manual Data Entry, Full Name Fields

As an option, a special template has been provided that contains a more complete description of the various data item fields (i.e., the description of the data fields are the same as those shown in Chapter V). These templates come from the NODE.FMT and LINK.FMT files. If the user wishes to use these special templates, the ".FMT" files must be copied into the same directory as the ".DBF" files discussed earlier. To use this template, execute the "SET FORMAT" command:

.USE <NODE or LINK>
.SET FORMAT TO <NODE or LINK>
.APPEND

- The file selected with the "USE" command (either the NODE or LINK ".DBF" files) must also be selected with the "SET FORMAT" command (NODE or LINK ".FMT" files). When the "APPEND" command is executed, the special template will appear.

- Data entry, as well as the order of the data fields, is the same as in Option 1.

OPTION 3: Automatic Computer Data Entry

If the data can be obtained from the State's database and be placed into an ASCII format, the file can be imported into dBase. The user can import the ASCII file into dBase with the following steps. Copy the NODE.DBF, LINK.DBF, and the ASCII files into the dBase working directory, and execute the following commands:

.USE <NODE or LINK>
.APPEND FROM <YourAsciiFile> TYPE <SDF>

The file (either NODE or LINK) that the user selects with the "USE" command must be appended with the corresponding Node or Link ASCII file. When preparing the ASCII file, the State must ensure that the field positions and lengths match those of the appropriate Node Data File and Inventory Route Link Data File in Chapter V. The ASCII file type used in this example is fixed length (shown in the above "APPEND" command as <SDF>), but dBase can accept other types of delimited ASCII files (check the dBase manual for appropriate ASCII type).

OPTION 4: ASCII File

This option does not use dBase. If the data can be obtained from the State's PC database and placed into an ASCII format, the file can be directly submitted to FHWA in that fashion. When preparing the ASCII file, the State must ensure that the field lengths and positions match those of the appropriate Node Data File and Inventory Route Link Data File in Chapter V. The ASCII file type should be fixed length, but if different, the file type should be fully explained in the correspondence.

OPTION 5: EBCDIC File

This option does not use dBase. If the data can be obtained from the State's mainframe database and placed into an EBCDIC format, the mainframe file may be downloaded to a PC and submitted to FHWA as an ASCII file.

APPENDIX I

CLIMATE ZONE DEFINITIONS

The HPMS climate zones and definitions have been taken from *A Pavement Moisture Accelerated Distress (MAD) Identification System*, Volume 2, September 1981, Report Number FHWA/RD-81/080. The report is the result of research done for FHWA by the University of Illinois. The HPMS software assigns the climate zones internally.

If an HPMS sample section appears to belong to a different climate zone than has been assigned on a countywide basis by the HPMS software, the State may change the climate zone (Item 52) based on the definitions contained in this Appendix. Note that the definitions have repetitive portions – there are three different interpretations of winter conditions and of wet/dry conditions. Using all possible combinations accounts for the nine possible climate zones.

CLIMATE ZONE 01: Wet; Freeze

This zone experiences long winters with the temperature below freezing for extended periods. The potential for a slowly advancing freezing front into the subgrade is extremely high. Frost damage is to be expected accompanied with other low temperature problems.

Due to the climatic influences, the subgrade will remain wet for the majority of the year and very little moisture variation will occur. Performance relationships indicate that the zone will maintain a moisture level that will produce low load-related performance.

CLIMATE ZONE 02: Wet; Freeze-Thaw

This zone experiences winters with more fluctuation of the temperatures about the freezing point. Freeze-thaw cycling into the base course is to be expected. Some thermal fatigue problems could be expected, with hot summers being a problem in the West due to radiation.

Due to the climatic influences, the subgrade will remain wet for the majority of the year and very little moisture variation will occur. Performance relationships indicate that the zone will maintain a moisture level that will produce low load-related performance.

CLIMATE ZONE 03: Wet; No Freeze

This zone is characterized by relatively mild winters (compared to 01, 02, 04, 05, 07 or 08) and damage may range from minimal thermal fatigue in the North to high temperature stability problems in the South.

Due to the climatic influences, the subgrade will remain wet for the majority of the year and very little moisture variation will occur. Performance relationships indicate that the zone will maintain a moisture level that will produce low load-related performance.

CLIMATE ZONE 04: Intermediate; Freeze

This zone experiences long winters with the temperature below freezing for extended periods. The potential for a slowly advancing freezing front into the subgrade is extremely high. Frost damage is to be expected accompanied with other low temperature problems.

The state of moisture in the subgrade will vary during the year, but the average moisture condition is very much drier than zones 01, 02, and 03. This zone produces a moisture state that produces load-related performance in a transitional portion between good and poor. Seasonal concentration of moisture will be important in determining which level of performance would be present.

CLIMATE ZONE 05: Intermediate; Freeze-Thaw

This zone experiences winters with more fluctuation of the temperatures about the freezing point. Freeze-thaw cycling into the base course is to be expected. Some thermal fatigue problems could be expected, with hot summers being a problem in the West due to radiation.

The state of moisture in the subgrade will vary during the year, but the average moisture condition is very much drier than zones 01, 02, and 03. This zone produces a moisture state that produces load-related performance in a transitional portion between good and poor. Seasonal concentration of moisture will be important in determining which level of performance would be present.

CLIMATE ZONE 06: Intermediate; No Freeze

This zone is characterized by relatively mild winters (compared to 01, 02, 04, 05, 07 or 08) and damage may range from minimal thermal fatigue in the North to high temperature stability problems in the South.

The state of moisture in the subgrade will vary during the year, but the average moisture condition is very much drier than zones 01, 02, and 03. This zone produces a moisture state that produces load-related performance in a transitional portion between good and poor. Seasonal concentration of moisture will be important in determining which level of performance would be present.

CLIMATE ZONE 07: Dry; Freeze

This zone experiences long winters with the temperature below freezing for extended periods. The potential for a slowly advancing freezing front into the subgrade is extremely high. Frost damage is to be expected accompanied with other low temperature problems.

In this zone, the annual moisture state is dry. The load-related performance is good for all materials. Seasonal concentrations of moisture will be responsible for producing slightly lower performance in one area versus another where the moisture is not concentrated in one time period.

CLIMATE ZONE 08: Dry; Freeze-Thaw

This zone experiences winters with more fluctuation of the temperatures about the freezing point. Freeze-thaw cycling into the base course is to be expected. Some thermal fatigue problems could be expected, with hot summers being a problem in the West due to radiation.

In this zone, the annual moisture state is dry. The load-related performance is good for all materials. Seasonal concentrations of moisture will be responsible for producing slightly lower performance in one area versus another where the moisture is not concentrated in one time period.

CLIMATE ZONE 09: Dry; No Freeze

This zone is characterized by relatively mild winters (compared to 01, 02, 04, 05, 07 or 08) and damage may range from minimal thermal fatigue in the North to high temperature stability problems in the South.

In this zone the annual moisture state is dry. The load-related performance is good for all materials. Seasonal concentrations of moisture will be responsible for producing slightly lower performance in one area versus another where the moisture is not concentrated in one time period.

APPENDIX J

HPMS SUBMITTAL SOFTWARE

INTRODUCTION

The Federal Highway Administration (FHWA) developed the HPMS software system to facilitate the submission and analysis of HPMS data in a microcomputer environment. The system provides the States with the ability to enter data directly into the system, view section-by-section data on the screen, modify section-by-section data on screen, validate the data, calculate data values, query the data for inconsistencies in the coding, and analyze current year data and compare them with prior years' data.

SYSTEM REQUIREMENTS

The software should be installed on at least a Pentium or Pentium II (preferred) 200 Mhz with MMX extensions or AMD K6 with 3D Now with at least 64 MB of memory (96 MB RAM or 128 MB RAM preferred) and at least a 4 gigabyte hard drive running Windows NT or Windows 98 or better. The resolution of the monitor should be at least 800 x 600 True Colors.

The software requires 20 MB of free space on C:\ for installation and approximately five times the size of the current HPMS data file free space for running the system. Without a sufficient amount of free space, the system will hang or display an error message while performing some of the processes. The free space must be on the same drive on which the software is installed and running.

If installed on a drive other than C:\, users still need 20 MB of free space on C:\. However, the drive on which HPMS is installed needs to be five times the size of the current HPMS data file. The software installation procedure initially copies compressed files to C:\ and decompresses them on the drive where the software will be installed. The software will use approximately 4 MB of space on the C:\ drive regardless of where the software is installed because of files that are placed in the Windows directory.

Please Note: Windows NT Version 4.0 users need service pack 5, or higher, installed on the PC. Service pack information can be found at the top of the screen when the computer is started and Windows is loading. The service pack information is displayed at the end of the line. Users can also go to Start, Program Files, Administrative Tools (Common), Windows NT Diagnostics and view the version information.

IMPORTING THE DATA

The State's roadway information data prepared for the HPMS submission is imported into the software system as a comma delimited ASCII file. The data must be coded as outlined in Chapter IV and must follow the table layout listed below.

The HPMS data is stored as a Microsoft Access table. Therefore, each data segment in the file must have a unique Section ID (data Item 5) within the county code (data Item 4); the Section ID must not contain all blanks or all zeros. These data items are two of the record keys for the HPMS table in the Microsoft Access database.

HPMS COMMA DELIMITED ASCII FILE

The layout for the comma delimited ASCII file that is imported into and exported from the HPMS Windows-based software is shown in the table below. The ASCII file contains items included in the HPMS field manual. The following table lists the data items in the order they appear in the ASCII file. The first five items are record keys for the HPMS table in the Microsoft Access database.

Item #	Item Name	Data Type	Max. Length
1	Year of the Data	Numeric; Integer	9999
2	State Code	Numeric; Codes	99
3	Is Metric	Numeric; Integer	9
4	County Code	Numeric; Codes	999
5	Section Identification	Character Field	Max 12 characters *
6	Is Standard Sample	Numeric; Codes	9
7	Is Donut Sample	Numeric; Codes	9
8	State Control Field	Character Field	Max 100 characters *
9	Is Section Grouped	Numeric; Codes	9
10	LRS ID	Character Field	Max 12 characters *
11	LRS Start Point	Numeric; Decimal	99999.999
12	LRS End Point	Numeric; Decimal	99999.999
13	Rural/Urban Designation	Numeric; Codes	9
14	Urbanized Area Sampling Technique	Numeric; Integer	9
15	Urbanized Area Code	Numeric; Integer	999
16	Nonattainment Area Code	Numeric; Integer	999
17	Functional System	Numeric; Codes	99
18	Generated Functional System	Numeric; Codes	9 **
19	National Highway System (NHS)	Numeric; Codes	9
20	Planned Unbuilt Facility	Numeric; Codes	9
21	Official Interstate Route Number	Character Field	Max 5 characters *
22	Route Signing	Numeric; Codes	9
23	Route Signing Qualifier	Numeric; Codes	9
24	Signed Route Number	Character Field	Max 8 characters *
25	Governmental Ownership	Numeric; Codes	9
26	Special Systems	Numeric; Codes	9
27	Type of Facility	Numeric; Codes	9
28	Designated Truck Route	Numeric; Codes	9
29	Toll	Numeric; Codes	9
30	Section Length	Numeric; Decimal	99999.999
31	Donut Area AADT Volume Group	Numeric; Integer	9
32	Standard Sample AADT Volume Group	Numeric; Integer	99
33	AADT	Numeric; Integer	9999999
34	Number of Through Lanes	Numeric; Integer	99
35	Measured Pavement Roughness (IRI)	Numeric; Decimal	999.99
36	Present Serviceability Rating (PSR)	Numeric; Decimal	99.9
37	HOV Operations	Numeric; Codes	9

Item #	Item Name	Data Type	Max. Length
38	Highway Surveillance Systems A	Numeric; Codes	9
39	Highway Surveillance Systems B	Numeric; Codes	9
40	Highway Surveillance Systems C	Numeric; Codes	9
41	Highway Surveillance Systems D	Numeric; Codes	9
42	Highway Surveillance Systems E	Numeric; Codes	9
43	Highway Surveillance Systems F	Numeric; Codes	9
44	Highway Surveillance Systems G	Numeric; Codes	9
45	Highway Surveillance Systems H	Numeric; Codes	9
46	Highway Surveillance Systems I	Numeric; Codes	9
47	Sample Identifier	Character Field	Max 12 characters *
48	Donut Area Expansion Factor	Numeric; Decimal	99999.999 **
49	Standard Expansion Factor	Numeric; Decimal	99999.999 **
50	Surface/Pavement Type	Numeric; Codes	9
51	SN or D	Numeric; Decimal	999.9
52	Climate Zone	Numeric; Codes	9
53	Year of Surface Improvement	Numeric; Integer	9999
54	Lane Width	Numeric; Decimal	999.9
55	Access Control	Numeric; Codes	9
56	Median Type	Numeric; Codes	9
57	Median Width	Numeric; Decimal	999.9
58	Shoulder Type	Numeric; Codes	9
69	Shoulder Width – Right	Numeric; Decimal	99.9
60	Shoulder Width – Left	Numeric; Decimal	99.9
61	Peak Parking	Numeric; Codes	9
62	Widening Feasibility	Numeric; Codes	9
63	Curves by Class A	Numeric; Decimal	99.999
64	Curves by Class B	Numeric; Decimal	99.999
65	Curves by Class C	Numeric; Decimal	99.999
66	Curves by Class D	Numeric; Decimal	99.999
67	Curves by Class E	Numeric; Decimal	99.999
68	Curves by Class F	Numeric; Decimal	99.999
69	Horizontal Alignment Adequacy	Numeric; Codes	9 **
70	Type of Terrain	Numeric; Codes	9
71	Vertical Alignment Adequacy	Numeric; Codes	9 **
72	Grades by Class A	Numeric; Decimal	99.999
73	Grades by Class B	Numeric; Decimal	99.999
74	Grades by Class C	Numeric; Decimal	99.999
75	Grades by Class D	Numeric; Decimal	99.999
76	Grades by Class E	Numeric; Decimal	99.999
77	Grades by Class F	Numeric; Decimal	99.999
78	Percent Passing Sight Distance	Numeric; Integer	999
79	Weighted Design Speed	Numeric; Integer	999 **
80	Speed Limit	Numeric; Integer	999
81	Percent Peak Single Unit Trucks	Numeric; Integer	999
82	Percent Average Daily Single Unit Trucks	Numeric; Integer	999

Item #	Item Name	Data Type	Max. Length
83	Percent Peak Combination Trucks	Numeric; Integer	999
84	Percent Average Daily Combination Trucks	Numeric; Integer	999
85	K-Factor	Numeric; Integer	99
86	Directional Factor	Numeric; Integer	999
87	Number of Peak Lanes	Numeric; Integer	99
88	Turning Lanes – Left	Numeric; Codes	9
89	Turning Lanes – Right	Numeric; Codes	9
90	Prevailing Type of Signalization	Numeric; Codes	9
91	Typical Peak Percent Green Time	Numeric; Codes	999
92	Number of At-Grade Intersections – Signals	Numeric; Integer	99
93	Number of At-Grade Intersections – Signs	Numeric; Integer	99
94	Number of At-Grade Intersections – Other	Numeric; Integer	99
95	Peak Capacity	Numeric; Integer	99999 **
96	Volume/Service Flow Ratio (V/SF)	Numeric; Decimal	9.99 **
97	Future AADT	Numeric; Integer	9999999
98	Future AADT Year	Numeric; Integer	9999

* Character fields do not use double quotes (“) within the data item.
** Field calculated by the software.

All fields should be separated by comma (**,**).
All character fields should be enclosed with double quotes (**“**).

For Numeric Data Items:

- Leading zero must be coded in a decimal value when the value is less than an integer (length = 0.21); otherwise, leading zeros are not required.
- Decimal points are required for all data items labeled “Numeric; Decimal”; i.e.,: those reported in tenths, hundredths, or thousandths (PSR=2.3, length = 8.253, etc.).
- One digit must be coded after a decimal point for all data items labeled “Numeric; Decimal”; PSR = 3 must be coded 3.0; additional trailing zeros are not required for the decimal portion of a data value.
- When data not available, code “0” or “0.0” as appropriate.

For Character Data Items:

- Any alphanumeric character (A through Z; 0 through 9; space) may be coded.
- DO NOT use double quotes within the character data item.
- Leading and embedded spaces are required, trailing spaces are optional.

For Data Items with Assigned Values (Codes):

- Select the appropriate value from the table.
- The value must be coded precisely as listed in the table.

HPMS record with Universe only information:

All 98 HPMS Data Items must be accounted for in the comma-delimited record. The record for a universe section would look like:

1999,44,0,1,"SECTION63810",0,0,"State Control Field",0,"000006395102",1.35,
10.0,4,0,26,26,14,0,0,0,"00000",3,0,"00000103",1,0,2,0,0,2.063,0,6,23145,4,0,3.5,0,0,0,0,0,0,0,0,0,0,,,,,,,,
,,,

51 commas are coded at the end for the sample data items.

The software calculates item 18 - Generated Functional System. A zero value must be used for all calculated fields.

There is no need to supply zero values for the sample portion of the record.

The following table corresponds to the above example:

Item #	Item Name	Data Value
1	Year of the Data	1999
2	State Code	44
3	Is Metric	0
4	County Code	1
5	Section Identification	SECTION63810
6	Is Standard Sample	0
7	Is Donut Sample	0
8	State Control Field	STATE CONTROL FIELD
9	Is Section Grouped	0
10	LRS ID	000006395102
11	LRS Start Point	1.35
12	LRS End Point	10.0
13	Rural/Urban Designation	4
14	Urbanized Area Sampling Technique	0
15	Urbanized Area Code	26
16	Nonattainment Area Code	26
17	Functional System	14
18	Generated Functional System	0
19	National Highway System (NHS)	0
20	Planned Unbuilt Facility	0
21	Official Interstate Route Number	00000
22	Route Signing	3
23	Route Signing Qualifier	0
24	Signed Route Number	00000103
25	Governmental Ownership	1
26	Special Systems	0
27	Type of Facility	2
28	Designated Truck Route	0
29	Toll	0
30	Section Length	2.063

Item #	Item Name	Data Value
31	Donut Area AADT Volume Group	0
32	Standard Sample AADT Volume Group	6
33	AADT	23145
34	Number of Through Lanes	4
35	Measured Pavement Roughness (IRI)	0
36	Present Serviceability Rating (PSR)	3.5
37	HOV Operations	0
38	Highway Surveillance Systems A	0
39	Highway Surveillance Systems B	0
40	Highway Surveillance Systems C	0
41	Highway Surveillance Systems D	0
42	Highway Surveillance Systems E	0
43	Highway Surveillance Systems F	0
44	Highway Surveillance Systems G	0
45	Highway Surveillance Systems H	0
47	Highway Surveillance Systems I	0
47-98	Sample Data Items	51 Commas are coded

ENTERING MANUAL CAPACITIES

The software system contains procedures to determine the capacity for each standard sample highway segment in the data. The procedures used in the HPMS software for calculating highway capacity conform to the Highway Capacity Manual (HCM). Capacity calculation procedures are described in Appendix N.

The capacity calculations are based on service flow rates for level of service E and are for the peak direction. The capacity coded in HPMS is used for system planning analysis, not project level analysis. The number of peak lanes (number of through lanes used in the peak period in the peak direction) coded in HPMS (Item 87) is used in the procedures for determining capacity. The number of through lanes coded in HPMS (Item 34) is used in the procedures to determine the number of lanes on the facility. The assumptions made by FHWA for adjustment factors used in the procedures are consistent with the recommended values in the HCM.

The user may override the calculated capacity if he/she determines that the capacity is too low or too high because of operational conditions that are not appropriately reflected in the HPMS data items used in the calculation. Once the capacity has been entered manually, the system will flag that highway segment and will not overwrite the capacity when running calculations. Once the switch is set, it will remain set for future year's data as well as for the current year's data. If in the future the user wants the system to calculate the capacity, enter a zero for the capacity for that highway segment. This will remove the flag the system has set for that highway segment in the data table.

A report, which lists all segments that have the capacity set by the user, is available. For each segment with a user set capacity the county code (Item 4), sample identifier (Item 47), section identification (Item 5) and peak capacity (Item 95) are listed.

ENTERING MANUAL GENERAL CLIMATE ZONE

The software system contains procedures to locate the standard sample highway segment in one of nine general climate zones. This numeric item is coded from county/climate zone equivalency tables. The definitions for the nine climate zones are included in Appendix I.

The climate zone should be checked and may be changed if found not to be representative of the area in question. The climate zone can be manually entered into individual highway segments or entered into the county name directory in the software. Entering the climate zone information into the county name directory will apply the new climate zone information to all sections in the county after running calculations. When entering the climate zone information segment-by-segment, the software flags the segments and will not overwrite the climate zone when running calculations. If in the future, the user does not want the manual climate zone coded, turn the flag off by entering a zero and the software will calculate the climate zone for the affected segment(s).

A report, which lists all segments that have the climate zone set by the user, is available. For each segment with a user set climate zone the county code (Item 4), sample identifier (Item 47), section identification (Item 5) and climate zone (Item 52) are listed.

BATCH UPDATING

Batch updating in the HPMS system assumes that a batch transaction file has been prepared outside of the system and is available for use. This file consists of a series of transaction records whose first 17 characters are in fixed field form which represent the action to take and the highway segment key on which to take the action. The fixed fields are:

Action Field (one character) in position 1 of the transaction record. The acceptable actions are:

A add a new highway segment or portion of a highway segment to the data table.

M modify an existing highway segment in the data table.

D delete an entire highway segment from the data table.

NOTE: Once the segment is deleted in a batch update the segment **cannot** be retrieved and put back in the table. It is recommended that the delete in the batch update be used with extreme care. If the segments are deleted using the EDITOR feature in the software one at a time, a table is built with the deleted segments and they can be retrieved if the wrong segment is deleted.

County Code (three characters) in positions 2 to 4 of the transaction record. Leading zeros must be coded.

Section Identifier (twelve characters) in positions 5 to 16 of the transaction record. If the transaction is to take place on an existing segment, M or D, the section identifier (Item 5) **must be** coded exactly as in the existing data segment. If the transaction is A, add a new segment to the data table, the section identifier **must not** match any existing section ID within the county.

Place Holder (one character) in position 17 **must be a** semicolon (;).

NOTE: If the action is **D**, delete an existing segment, the transaction would end with the 17 positions coded.

Starting in position 18, code the transaction specific information. This information consists of a repeating set of data including:

Data Item Number (as contained in Chapter IV) followed by a comma (,).

Data Value (specific to the item number- see comma delimited ASCII file description) followed by a semicolon (;). The types of data values are:

Assigned values (codes) – the value must be coded precisely as listed in the table with the codes for the particular data item.

Character data – any alphanumeric character (A through Z; 0 through 9; space) may be coded. Do **not** use double quotes ("), a comma (,) or a semicolon (;) within the character string. Leading or embedded spaces **are** required. Trailing spaces **are not** required.

Numeric data may be either **integer** or **decimal**. Leading zeros **are not** required for an integer. A leading zero **must be** coded in decimal values when the value is less than an integer (length = 0.21); otherwise, leading zeros **are not** required. Decimal points **are** required and one digit **must be** coded after the decimal point (PSR = 3, code 3.0); additional trailing zeros **are not** required for the decimal portion. When data are not reported or missing, code "0" or "0.0" as appropriate.

These sets (data item number, data value;) are repeated until the batch update information for a particular highway segment key is specified on the transaction record. There is no limit to the length of the transaction record. The set **must** end with a semicolon (;).

The data item number **must be** coded as listed for the data item in Chapter IV. To code the right shoulder width to "10" one would code 59,10;. The State Control Field, Item 8, needs to have only the positions used coded – i.e., to code the data in the 5-15th positions of the 100 character field, one would code:

bbbbMain Street; (where 'b' indicates a space would be coded)

If the **action field is M**, modify an existing segment in the data, the section identifier in the transaction record **must be** coded exactly as the section ID (Item 5) in the data table. If the segment section ID includes leading spaces and embedded spaces, they **must be** coded in the exact same position in the 12-character section identifier in the transaction record.

If the **action field is A**, add a new section, all data items for the universe, donut, or standard sample segment do not have to be coded on the transaction set (data item number, data value;). The rural urban designation (Item 13), functional system (Item 17), and section length (Item 30) **must be coded** for any section added. When adding a sample segment, either donut or standard sample, the sample identifier (Item 47) **must be coded** along with any data items beyond item number 49. For the added segment numeric data items not coded will be set to zero in the data table and character fields will be blank. The section identifier coded on the transaction record **must not** be the same as any section ID (Item 5) for an existing segment in the county where the segment to be added is located.

When doing a batch update the following rules apply:

- **Do not** delete a segment and add the same segment in the same execution.
- **Do not** add a segment and then modify that segment in the same execution.
- The only validation of the data values is that a numeric field cannot contain a character value.

Reports are generated which summarize the results of the batch update.

Examples:

A001TEST ADD 111;8,Peach Street;13,2;17,16;25,1;

Add a universe segment in county 001 with section ID TEST ADD 111. The segment is on Peach Street in a small urban area, functional system 16, and is owned by the State.

M003R17 003 3285;19,4;34,6;87,3;

Modify an existing segment in county 003 with section ID R17 003 3285. Three data items are to be updated – NHS, number of through lanes and number of peak lanes.

D112U22112144875;

Delete an existing segment in county 112 with ID U22112144875. Once the segment is deleted it cannot be retrieved.

A123ADDSAMP34186;8,STATE HIGHWAY 34;13,1;17,2;19,1;47,341 86 12323;54,12;55,2;

Add a standard sample segment in county 123 with ID ADDSAMP34186 on State Highway 34. The segment is rural, functional system 2, on the NHS, sample identifier 341 86 12323, lane width 12, and access control 2.

SUBMIT HPMS DATA TO FHWA

The software is used by the State to submit the HPMS data annually to FHWA by June 15th. The data may be submitted electronically, on a CD-ROM, or on a diskette. Included with the data should be a comment file which addresses any remaining issues with the data – validation errors which are valid for the State, missing data not collected, etc. The comment file should be saved as a rich text format (RTF) file from the software used to create the file.

APPENDIX K

SAMPLE ADEQUACY ASSESSMENT SOFTWARE

INTRODUCTION

The sample adequacy assessment provides a comparison of the actual number of samples to the required number of samples as defined in Chapter VII and Appendices C and D of this Manual. Analysis of the reports provided will indicate where more samples are required or where some samples may possibly be deleted (see explanations for columns 21 and 25 of the reports). The number of existing and required samples is determined for each functional system for each AADT volume group by rural, small urban and individual urbanized area or collective urbanized area for the standard sample panel and for each nonattainment area donut area sample panel.

To obtain the Sample Adequacy reports, select *Analysis/Sample Management/Adequacy* from the menu bar in the HPMS Submittal Software. Either the reports can be sent directly to the printer by pressing the *Print* button or they can be viewed on the screen by pressing the *Preview* button.

Any data file to be processed for sample adequacy assessment should contain CLEAN, EDITED, and CORRECTED data and have volume groups and expansion factors assigned.

The standard sample adequacy assessment output consists of several reports based on Appendix D (Sample Size Estimation Procedures).

- Sheet 1 of Report ADEQ-01 contains a summary of the current standard sample and universe data by functional system and AADT volume group.
- Sheet 2 of Report ADEQ-01 contains the Appendix D calculations for the estimated number of required samples, the difference from the current number of unique standard samples as well as the estimated (or actual) universe records and length, for the same functional system and appropriate volume group strata.

There are Sheet 1/Sheet 2 report pairs as indicated above for each of the following:

- Rural
- Small Urban
- Each Urbanized Area and/or Collective Grouping of Urbanized Areas

The donut area sample adequacy assessment reports follow the standard sample adequacy reports, if any donut areas exist. This report consists of two sheets for each donut area:

- Sheet 1 of Report ADEQ-02 contains rural and small urban universe counts and length values summarized by the appropriate functional systems and volume groups.
- Sheet 2 of Report ADEQ-02 contains rural and small urban donut area sample information summarized by volume group for the combined rural and small urban minor arterial and combined rural major collector and small urban collector systems.

REPORT FIELD DESCRIPTIONS

This section describes the contents of each column in the reports and should be read and understood before the reports are used.

NOTES:

Some of the subtotals and totals may not equal the sum of the entries making up that total. This is because the line-by-line values are rounded as they are printed, while the actual values are accumulated for the totals and are not rounded until the totals are printed. The differences should be small.

The title lines identify which Appendix C table was used for the confidence levels and precision rates (see Columns 26 and 27 of Sheet 2 of any report). The title line messages and the conditions under which each will appear are as follows:

Title Line Message	Condition Under Which Each Will Appear
Using Appendix C, Table C-1	For rural areas.
Using Appendix C, Table C-2	For small urban areas.
Using Appendix C, Table C-3/ Individual Areas (<3)	For urbanized areas with population less than 200,000 (rural/urban code is 3), where there are fewer than 3 individual urbanized areas in the State.
Using Appendix C, Table C-3/ Individual Areas (3 or More)	For urbanized areas with population less than 200,000 (rural/urban code is 3), where there are 3 or more individual urbanized areas in the State.
Using Appendix C, Table C-3/ Collective Areas	For collective urbanized areas. These areas will be reported in column 4 with an area code of 901 to 909.
Using Appendix C, Table C-4	For urbanized areas with population greater than 200,000 (rural/urban code is 4), or for urbanized areas with a population less than or equal to 200,000 (rural/urban code is 3) which are also in a nonattainment area.
Using Appendix C, Table C-5	For donut areas of nonattainment areas.

EXPLANATION OF COLUMNS IN SHEETS 1 AND 2 OF REPORTS ADEQ-01 AND ADEQ-02

HPMS DATA

These columns classify the data from both the sample and the universe. Sample column comments apply to both standard and donut area samples. If there is a difference, it is explained.

Column 1 – Functional System: This column contains HPMS Item 17, functional system code. All local (Item 17 = 9 or 19) and rural minor collector (Item 17 = 8) functional system records are excluded from this analysis.

For a donut area, this column will contain rural minor arterial (Item 17 = 6) followed by small urban minor arterial (Item 17 = 16), then by a summary Item 17 = 6, 16 line; this is followed by rural major collector (Item 17 = 7), then small urban collector (Item 17 = 17) and a summary Item 17 = 7, 17 line.

Column 2 – R/U Code: This column contains HPMS Item 13, rural/urban designation code. This code is used as the basis for the precision levels used in the Appendix D calculations.

Column 3 – Volume Group: This is either the standard sample AADT volume group identifier, Item 32 (codes 1-13 in Report ADEQ-01) or the donut area sample AADT volume group identifier, Item 31 (codes 1-5 in Report ADEQ-02). The text that follows describes other entries that may be coded in addition to the numeric volume group codes:

- "**G**" as a Suffix after the Volume Group: Indicates that the values on this line are for Grouped length data (Item 9 = 1). The AADT volume group is known (it is a required data item) but the actual AADT is not known since it is likely assigned (or coded zero) for the group of sections. On Sheet 1 of the report, these values will be reported separately; while on Sheet 2 of the report, an estimate of the number of sections in the group will be included with the actual number of sections (see Column 16). Column 3 also appears on Sheet 2 of Reports ADEQ-01 and ADEQ-02 for control purposes. The "**G**" suffix print line appears on Sheet 2 (even though no data appears on these lines) to enable easy comparison between Sheets 1 and 2.

- **TOTAL** – For standard samples, this indicates totals for a functional system.

  For donut area samples, **TOTAL** indicates totals for a combined functional system (Item 17 = 6,16 or Item 17 = 7,17).

- **GRTOT** – For standard samples, this indicates the grand total for the sheet (rural, small urban, individual urbanized area, or collective urbanized group).

  For donut area samples, **GRTOT** indicates the grand total for the donut area of a nonattainment area.

Column 4 – Urbanized Area Code: This will be zero (dash) for rural and small urban entries, and will identify the individually sampled urbanized areas, Item 15 (as taken from Appendix B). Collective urbanized areas will be identified as "901" for group 1 (Item 14 plus 900); "902" for group 2; etc.

Report ADEQ-02 contains the nonattainment area code for the donut area.

SAMPLE DATA

These columns include summaries only from those records that are samples.

Column 5 – Number of Samples: This is a count of the number of samples. The resulting records are then used to develop Column 10, the sample AADT coefficient of variation; this is also the "current" value used to calculate the number of required samples in Columns 18 and 22.

Column 6 – Unexpanded Length: This is the accumulated sample length of the total number of sections contained in Column 5.

Column 7 – Average Section Length: Obtained by dividing Column 6 by Column 5, and is for information purposes only.

Column 8 – Expanded Length: The sum of the expansion factor times the length for all of the sections in the volume group (Column 5). This value should agree with the total universe length (Column 11). If some universe records in a volume group have been grouped, they are summarized in the line below the ungrouped sections. The two Column 11 lengths must be summed to make a valid check with Column 8 for the particular volume group.

Column 9 – Expansion Factor: This column contains the standard expansion factor (Item 49) or the donut area expansion factor (Item 48). If all records of a volume group do not have the same expansion factor, the first expansion factor encountered will be contained in this column.

Column 10 – AADT Coefficient of Variation (C.V.): This is computed by dividing the AADT standard deviation by the mean AADT for each volume group using only the samples identified as unique (Column 5). The calculated C.V. is the "C" value used in the Appendix D formula for calculating the required number of samples in Column 18.

If there are no samples (or only one) in the volume group with AADT coded, the coefficient of variation cannot be calculated. Under this circumstance, predetermined coefficients are used (if the predetermined (default) value is used, a "T" will follow the value). This mainly occurs where the universe AADT data has a volume group that is not sampled or all samples in the volume group contain the same AADT, but could also happen when there is undersampling. The same rule applies to the universe coefficient in Column 14. When the computed C.V. value is less than 0.005, the default values will also be used. This usually occurs when the difference in AADT values among records is very small.

If a sample record has no AADT coded, it will be excluded from the C.V. computation and an asterisk (*) will follow the C.V. value.

If both a "T" (default table used) and an "*" (one or more AADT values of zero) apply to a particular volume group, only the "T" notation will appear.

UNIVERSE DATA

These columns contain a summary of all HPMS records, including samples.

Column 11 – Length: The total length for the volume group. Lengths of grouped records (Item 9 = 1) are contained on the lines where Column 3 has the "**G**" suffix.

Column 12 – Number of Sections: A count of the number of HPMS records representing the volume group. Grouped length records (Item 9 = 1) are contained on the lines where Column 3 has the "**G**" suffix.

Column 13 – Average Section Length: Column 11 divided by Column 12. The ungrouped average value is used to calculate the estimated number of sections for the grouped sections, if needed–see the explanations for Columns 15 and 17.

Column 14 – AADT Coefficient of Variation (C.V.): As described for Column 10, but in this case all universe records that contain AADT are used.

If a universe record has no AADT coded, it will be excluded from the C.V. computation and an asterisk (*) will follow the C.V. value.

If there is only one universe record (or only one with an AADT value), the C.V. will be taken from default values contained in the software and a "T" will follow the C.V. value.

The calculated or default C.V. is the "C" value used in the Appendix D formula for calculating the number of samples required (Column 22). Grouped length records (Item 9 = 1) identified by a "**G**" suffix in Column 3 and total lines (**TOTAL** and **GRTOT**) will not have a coefficient of variation.

FROM UNIVERSE DATA

Estimations (where applicable) are made for the number of records in each volume group based on what is known from the existing data.

Column 15 – Estimated Number of Sections: This column contains the actual number of universe records in each volume group from Column 12 unless records for grouped length (Item 9 = 1; "**G**" suffix in Column 3) were included. Where there were grouped length records, the estimated number of sections is computed as the sum of the actual number of sections in Column 12 plus the total length (Column 11) for the grouped length records for that volume group divided by the average section length (Column 13) for those sections that were not grouped. Note that for this calculation, if the average section length exceeds 10.00 miles per section, the value 10.00 will be used.

This value becomes "N" in the Appendix D formula for calculating the required number of samples.

Column 16 – "EST" if Estimate Made: If Column 15 contains an estimate of the number of sections as described under Column 15 (from grouped length records), the abbreviation "EST" appears in this column for the volume groups involved. If "EST" is not present, the actual number of sections was brought forward from Column 12 (universe data) and placed in Column 15.

Column 17 – Combined Length: This column contains the combined universe length for each volume group from the two possible Column 11 entries; the one for the non-grouped length records plus the one for the grouped length records, if any existed.

The rest of the columns contain calculated values and values used in the calculations.

FROM THE SAMPLE AADT COEFFICIENT OF VARIATION (C.V.)

Column 18 – Number of Required Samples: This is the result of using the C.V. developed from the sample data (Column 10), the number of sections available for sampling (Column 15), and the confidence level value and precision rate contained in Columns 26 and 27 (from Appendix C) as input to the formula in Appendix D.

An asterisk (*) following the number of required samples in this column indicates that the required number of samples calculated from the Appendix D formula results in an estimated expansion factor greater than 100.000. The number of samples contained in Column 18 includes the original calculated value plus those contained in Column 19 so that the expansion factor would not exceed 100.000. For example, if the computed required number of samples resulted in an expansion factor of 110.000, the number of samples contained in this column has been increased by the number of samples indicated in Column 19 to keep the expansion factor at 100.000 or less. The analyst may want to consider increasing the number of samples even further above this value to allow for future changes.

This calculation is made in addition to the one based on the universe C.V. (Column 22) for comparison purposes and to provide a choice to the State based upon where the more accurate AADTs are encoded. If the State believes that the universe AADTs are accurate throughout, then the Column 14 C.V. should be used and Column 22 is considered a reasonable estimate of the sample requirement.

NOTE: Once a State elects to use either the sample estimate (column 18) or the universe estimate (column 22), the entire sample panel is to be based on that estimation criteria (sample or universe).

Column 19 – Number of Factor Samples: This column contains the number of samples that were added to the calculated number so that the estimated expansion factor would not exceed 100.000. If the number of required samples as originally calculated for Column 18 resulted in an expansion factor greater than 100.000, an asterisk (*) will appear in Column 18. Column 19 will indicate how many additional samples were required to keep the expansion factor from exceeding 100.000.

Column 20 – New Expansion Factor: This column contains the estimated expansion factor that would result from the number of samples shown in Column 18. If there is an asterisk (*) in Column 18, the expansion factor is the result after the number of samples shown in Column 19 has been added.

Column 21 – Difference: Required Samples Minus the Current Samples: Column 18 minus Column 5. A minus value indicates that the volume group has more than enough samples to be statistically sound. While differences in the range of + or - 10 percent may be generally ignored, several other considerations are needed before making any final decisions about, or changes to, the State's sample panels:

1. A prerequisite to doing anything is to ensure that the AADT data are up to date and accurate, and that all applicable records have been included in the analysis. Otherwise, this analysis cannot be considered a true assessment of the State's sample adequacy.
2. A comprehensive report of intended actions for <u>reductions</u> in the number of samples is to be submitted to FHWA Headquarters, HPPI-20 **BEFORE** any such action actually takes place. Random deletion of samples is a must in any such plan. The reduction plan will be evaluated at FHWA Headquarters and appropriate remarks will be returned via the FHWA field offices.

   Note: Sample section additions may take place at any time without FHWA evaluation.
3. A volume group must contain a minimum of three samples or all that are available if there are less than three universe records in the volume group.
4. The expansion factor should not be greater than 100.000 to ensure a statistically sound sample panel, and probably should be kept at even lower levels to provide for change over time.

5. If a State is using the HPMS Analytical Process, HERS, or is using the HPMS sample panel for other purposes, it may want to consider using higher confidence levels and/or precision rates than were used in these calculations; this will result in a larger number of required samples, of course.
6. FHWA recommends that the number of samples not be reduced below a 10-percent difference, if more than that difference already exists (i.e., if 32 samples are required, 35 or so should be retained if a volume group already contains more than 35). This will provide for movement of samples and universe records into other volume groups over time.
7. The State should examine its AADT trends, the shifting of samples from one volume group to another over the years, the future expectations of AADT change, and other factors concerning AADT before making decisions concerning reductions in the number of samples.
8. This summary is an <u>ESTIMATE</u>. The State should do its own analysis, or at a minimum, ensure that this summary is a reasonable estimate of the State's sample panel requirements (particularly where estimates for the number of volume group records have been made in Column 15).

   Additional information about sample panel reduction is contained in Chapter VII.

9. Unsampled or undersampled volume groups must also be addressed, under any sample panel review.

FROM THE UNIVERSE AADT COEFFICIENT OF VARIATION (C.V.)

Column 22 – Number of Required Samples: This is the result of using the C.V. developed from the universe data (Column 14), the number of sections available for sampling (Column 15), and the confidence level value and precision rate contained in Columns 26 and 27 (from Appendix C) as input to the formula in Appendix D.

An asterisk (*) could appear in this column; see explanation under the description for Column 18.

This calculation is made in addition to the one based on the sample C.V. (Column 18) for comparison purposes and to provide a choice to the State based upon where the more accurate AADTs are encoded. See the discussions under Columns 18, 19, 20, & 21 for more details.

Column 23 – Number of Factor Samples: This column contains the number of samples that were added to the calculated number so that the estimated expansion factor would not exceed 100.000 (see Column 18 for explanation). If the number of required samples as originally calculated for Column 22 resulted in an expansion factor greater than 100.000, an asterisk (*) will appear in Column 22. This Column (Column 23) will indicate how many additional samples were required to keep the expansion factor from exceeding 100.000.

Column 24 – New Expansion Factor: This column contains the estimated expansion factor that would result from the number of samples shown in Column 22. If there is an asterisk (*) in Column 22, the expansion factor is the result after the number of samples shown in Column 23 has been added.

Column 25 – Difference: Required Samples Minus the Current Samples: Column 22 minus Column 5. See the discussions under Columns 18, 19, 20, & particularly 21 for more information on the uses, ramifications, and cautions concerning these differences.

Column 26 – Standard Value for the Confidence Level: The standard values come from statistical handbooks and are used as “Z” in the Appendix D formula for calculating the number of required samples:

Value	Confidence Level
1.645	90 Percent
1.282	80 Percent
1.04	70 Percent

The confidence levels come from the tables in Appendix C. The State may wish to raise these levels if it plans to use the HPMS sample panel for its own purposes and requires higher levels of confidence.

Column 27 – Precision Rate Desired: The precision rates come from the tables in Appendix C and are used as “d” in the Appendix D formula for calculating the number of required samples. The State may wish to raise these rates if it plans to use the HPMS sample panel for its own purposes and requires more precision.

APPENDIX L

METRIC/ENGLISH CONVERSION PROCEDURES

INTRODUCTION

The HPMS software is capable of converting HPMS files from English to metric and vice versa when using the import process. The units are set by selecting *Admin Tools/Change State/Year*. Once the data have been imported into the system, the units cannot be changed. If a State chooses to work in different units, the data must be exported and then reimported after the units are reset.

All data are converted to metric by the HPMS software during the submittal process, *FHWA Submittal/Send Submittal.*

The following data items are converted:

Item No.	Description	Conversion Units
3	Reporting Units	Codes 0 (English);1 (Metric)
11-12	LRS MPT/KMPT	Miles - Kilometers
30	Section Length	Miles - Kilometers
35	Roughness (IRI)	Inches/Mile - Meters/Kilometer
51	D (Slab Thickness)	Inches - Millimeters
54	Lane Width	Feet - Meters
57	Median Width	Feet - Meters
59-60	Shoulder Width (Right and Left)	Feet - Meters
63-68	Curves (6 Values)	Miles - Kilometers
72-77	Grades (6 Values)	Miles - Kilometers
79	Weighted Design Speed	MPH - km/h
80	Speed Limit	MPH - km/h

HARD CONVERSION

Hard conversion is accomplished via a table lookup where a current value is converted directly to a predetermined value. In these cases, the computed rounded values may not always be identical to the soft conversion value. Hard conversion is used whenever possible for the following items:

Item	Data
54	Lane Width
59-60	Right and Left Shoulder Width
79	Weighted Design Speed
80	Speed Limit

For current lane or shoulder widths from 0.3 meters to 5.6 meters (1 foot to 18 feet), the hard conversion value is as found in Tables L-3 (English to metric) and L-4 (metric to English) for Items 54, 59, and 60. Any current value which is less than the lower limit or greater than the upper limit of the appropriate portion of these tables is converted using a soft conversion (e.g., 32 feet becomes 9.8 meters).

Weighted design speed (Item 79) and speed limit (Item 80) should be coded in multiples of 5. If coded in multiples of 5, and if within the limits of Tables L-1 (5 to 75 miles per hour) or L-2 (10 to 120 kilometers per hour), a hard conversion is used; otherwise, a soft conversion is made. Where there is no speed limit, code "A999" is used for either metric or English.

SOFT CONVERSION

A soft conversion is a computation using the current value times a conversion factor to produce a converted value (e.g., 13 feet x 0.3048 meter/foot = 3.9624 meters). Any computed value is then rounded to the required number of decimal positions (e.g., 3.9624 meters becomes 4.0 meters for a 1 decimal place precision).

The following list of factors are used when making soft conversions:

Field Units Being Converted	English to Metric	Metric to English
Miles - Kilometers	1.609344	1 / 1.609344
Feet - Meters	0.3048	1 / 0.3048
Inches per Mile - Meters per Kilometer	1 / 63.36	63.36
Inches - Millimeters	25.4	1 / 25.4
MPH - km/h	1.609344	1 / 1.609344

Soft conversion is used on the following data items:

Item No.	Description	Conversion Units
11-12	LRS MPT/KMPT	Miles - Kilometers
30	Section Length	Miles - Kilometers
35	Roughness (IRI)	Inches/Mile - Meters/Kilometer
51	D (Slab Thickness)	Inches - Millimeters
57	Median Width	Feet - Meters
63-68	Curves by Class	Miles - Kilometers
72-77	Grades by Class	Miles - Kilometers

Table L-1. Hard Conversion for Speed
ENGLISH TO METRIC — Using Factor 1.609344

MPH	km/h Hard Conversion	km/h Computed
5	**10**	8.05
10	**15**	16.09
15	**25**	24.14
20	**30**	32.19
25	**40**	40.23
30	**50**	48.28
35	**60**	56.33
40	**65**	64.37
45	**70**	72.42
50	**80**	80.47
55	**90**	88.51
60	**100**	96.56
65	**105**	104.61
70	**110**	112.65
75	**120**	120.70
BOLD indicates what is used for hard conversions.		
Values beyond 75 MPH and those that are NOT multiples of 5 use soft conversions rounded to the nearest km/h.		

Table L-2. Hard Conversion for Speed
METRIC TO ENGLISH — Using Factor 1 / 1.609344

km/h	MPH Hard Conversion	MPH Computed
10	**5**	6.21
15	**10**	9.32
20	**10**	12.43
25	**15**	15.53
30	**20**	18.64
35	**20**	21.75
40	**25**	24.85
45	**30**	27.96
50	**30**	31.07
55	**35**	34.18
60	**35**	37.28
65	**40**	40.39
70	**45**	43.50
75	**45**	46.60
80	**50**	49.71
85	**55**	52.82
90	**55**	55.92
95	**60**	59.03
100	**60**	62.14
105	**65**	65.24
110	**70**	68.35
115	**70**	71.46
120	**75**	74.56
BOLD indicates what is used for hard conversions.		
Values beyond 10 km/h, beyond 120 km/h and those that are NOT multiples of 5 use soft conversions rounded to the nearest MPH.		

Table L-3. Hard Conversion for Length
ENGLISH TO METRIC — Using Factor 0.3048

	Feet	Meters Hard Conversion	Meters Computed
Lane Width	6	**1.8**	1.83
	7	**2.1**	2.13
	8	**2.4**	2.44
	9	**2.7**	2.74
	10	**3.0**	3.05
	11	**3.3**	3.35
	12	**3.6**	3.66
	13	**3.9**	3.96
	14	**4.2**	4.27
	15	**4.5**	4.57
	16	**4.8**	4.88
	17	**5.2**	5.18
	18	**5.5**	5.49
Shoulder Width	1	**0.3**	0.30
	2	**0.6**	0.61
	3	**0.9**	0.91
	4	**1.2**	1.22
	5	**1.5**	1.52
	6	**1.8**	1.83
	7	**2.1**	2.13
	8	**2.4**	2.44
	9	**2.7**	2.74
	10	**3.0**	3.05
	11	**3.3**	3.35
	12	**3.6**	3.66

BOLD indicates what is used for hard conversions.

Values not shown for the item of interest are soft converted and rounded to the nearest tenth of a meter.

Table L-4. Hard Conversion for Length

METRIC TO ENGLISH — Using Factor 1 / 0.3048

	Meters	Feet Hard Conversion	Feet Computed
Lane Width	1.7	**6**	5.57
	1.8	**6**	5.90
	1.9	**6**	6.23
	2.0	**7**	6.56
	2.1	**7**	6.89
	2.2	**7**	7.21
	2.3	**8**	7.54
	2.4	**8**	7.87
	2.5	**8**	8.20
	2.6	**9**	8.52
	2.7	**9**	8.85
	2.8	**9**	9.18
	2.9	**10**	9.51
	3.0	**10**	9.84
	3.1	**10**	10.16
	3.2	**10**	10.49
	3.3	**11**	10.82
	3.4	**11**	11.15
	3.5	**11**	11.48
	3.6	**12**	11.80
	3.7	**12**	12.13
	3.8	**12**	12.46
	3.9	**13**	12.79
	4.0	**13**	13.11
	4.1	**13**	13.44
	4.2	**14**	13.77
	4.3	**14**	14.10
	4.4	**14**	14.43
	4.5	**15**	14.75
	4.6	**15**	15.08
	4.7	**15**	15.41
	4.8	**16**	15.74
	4.9	**16**	16.07
	5.0	**16**	16.39

	Meters	Feet Hard Conversion	Feet Computed
Lane Width (continued)	5.1 5.2 5.3	**17** **17** **17**	16.72 17.05 17.38
	5.4 5.5 5.6	**18** **18** **18**	17.70 18.03 18.36
Shoulder Width	0.3 0.4	**1** **1**	0.98 1.31
	0.5 0.6 0.7	**2** **2** **2**	1.64 1.97 2.30
	0.8 0.9 1.0	**3** **3** **3**	2.62 2.95 3.28
	1.1 1.2 1.3	**4** **4** **4**	3.61 3.93 4.26
	1.4 1.5 1.6	**5** **5** **5**	4.59 4.92 5.25
	1.7 1.8 1.9	**6** **6** **6**	5.57 5.90 6.23
	2.0 2.1 2.2	**7** **7** **7**	6.56 6.89 7.21
	2.3 2.4 2.5	**8** **8** **8**	7.54 7.87 8.20
	2.6 2.7 2.8	**9** **9** **9**	8.52 8.85 9.18
	2.9 3.0 3.1 3.2	**10** **10** **10** **10**	9.51 9.84 10.16 10.49
	3.3 3.4 3.5	**11** **11** **11**	10.82 11.15 11.48

	Meters	Feet Hard Conversion	Feet Computed
Shoulder Width (continued)	3.6 3.7 3.8	**12** **12** **12**	11.80 12.13 12.46
BOLD indicates what is used for hard conversions.			
Values not shown for the item of interest are soft converted and rounded to the nearest foot.			

APPENDIX M

PROCEDURES FOR ESTIMATING WEIGHTED DESIGN SPEED

Weighted design speed (WDS) is defined as the weighted average of the design speeds within the section, when each curve and tangent segment within the section is considered to have an individual design speed.

The weighted design speed is determined for each paved standard sample section. If the section has curve data coded, the curve data is used to determine the weighted design speed. When curve data is not coded for the sample section, the weighted design speed is a default value based on functional system and facility type.

Section with Curve Data Coded

When the paved sample section has curve length reported for at least one of the curve classes, the coded curve length(s) are used to determine the weighted design speed.

Curve Classes			Length of Curves in Class (Miles)
Curve Class	**Radius Length (Metric)**	**Degree of Curvature (English)**	
A	506+	0.0-3.4	xx.xxx
B	321-5-5	3.5-5.4	xx.xxx
C	206-320	5.5-8.4	xx.xxx
D	126-205	8.5-13.9	xx.xxx
E	61-125	14.0-27.9	xx.xxx
F	< 61	28+	xx.xxx

Weighted Design Speed = (Sample Section Length / Total Travel Time) * 60 minutes/hour

Where: Total Travel Time (in minutes) = Sum of the travel time for each curve class with a length coded for the class.

The travel time for each curve class (A-F) with a nonzero length is:

Travel Time = (60 / Design Speed for the Curve Class) * Length of Curve Class

Where the design speed for the curve class is defined in the following table:

Curve Class	Design Speed (MPH)
A	70
B	60
C	50
D	40
E	30
F	25

Section with Curve Data NOT Coded

When the paved sample section does not have curve data coded for the section (all curve classes have length coded zero), the weighted design speed is a default value based on functional system and facility type.

The default table is defined as:

	Functional System								
Facility Type	1	2	6	7	11	12	14	16	17
Multilane Divided	70	70	70	65	70	70	70	60	55
Multilane Undivided	70	70	70	60	70	70	70	55	45
2 or 3 Lane	70	70	65	60	70	65	65	55	45

A multilane divided roadway is a section with four or more through lanes and a median type of curbed or positive barrier or median width greater than or equal to four feet. A multilane undivided roadway is a section with four or more lanes without a qualifying median.

Rounding the Weighted Design Speed

The weighted design speed is rounded to the nearest 5 MPH using the following rules:

WDS	< 32.5	set to 30 MPH
WDS	32.5 to < 37.5	set to 35 MPH
WDS	37.5 to < 42.5	set to 40 MPH
WDS	42.5 to < 47.5	set to 45 MPH
WDS	47.5 to < 52.5	set to 50 MPH
WDS	52.5 to < 57.5	set to 55 MPH
WDS	57.5 to < 62.5	set to 60 MPH
WDS	62.5 to < 67.5	set to 65 MPH
WDS	>= 67.5	set to 70 MPH

Determining the WDS for a Section

A worksheet for WDS calculation is provided in Figure M-1. The steps to be taken are as follows:

1. For the section of highway being analyzed, list each nonzero length for the appropriate class in the column headed "Length of Curves in Class."
2. For each curve class with length entered, determine the Travel Time by dividing 60 by the Design Speed for the curve class and multiply by the "length of curve in class". Enter this value in the column labeled "Travel Time."
3. Total the Travel Time for each curve class.
4. Divide the sample section length by the Total Travel Time and then multiply by 60 minutes/hour to obtain the WDS in miles per hour.
5. Round to the nearest 5 MPH.

A sample calculation is shown on the worksheet, Figure M-1. For a rural section, curve class D has a length of 1.20 miles for a travel time of 1.8 minutes, curve class B a length of 1.3 miles for a travel time of 1.3 minutes and curve class A a length of 3.0 miles for a travel time of 2.57 minutes. The total travel time for the curves is 5.67 minutes. The section length (5.50 miles) divided by the total travel time (5.67 minutes) and multiplied by 60 (minutes/hour) yields a WDS of 58.2 MPH. This is then rounded to 60 MPH.

Curve Category[1]	Degree of Curvature[2]	Approximate Design Speed	Length of Curves in Class	Travel Time (Minutes) ((60/Design Speed) * Length of Curves)
F	28.0 +	25		
E	14.0 - 27.9	30		
D	8.5 - 13.9	40	1.20	1.8
C	5.5 - 8.4	50		
B	3.5 - 5.4	60	1.3	1.3
A	0.0 - 3.4	70	3.0	2.57
		Total Travel Time (in minutes)		5.67

Section Length: **5.50** miles

Weighted Design Speed =
(Section Length (**5.50** miles) divided by Total Travel Time (**5.67** minutes)) * 60 minutes/hour

= **58.2** MPH; Rounded WDS = **60** MPH

Figure M-1. Worksheet for Calculating Weighted Design Speed (WDS)

1 Curve categories are from Curves by Class (Items 63-68 in Chapter IV).
2 For maximum super elevation rate of 0.08 foot/foot.

APPENDIX N

PROCEDURES FOR ESTIMATING HIGHWAY CAPACITY

HPMS SOFTWARE

The procedures used in the HPMS software for determining highway capacity conform to the Highway Capacity Manual 2000 (HCM 2000). The capacity calculations are based on service flow rates for level of service E and are for the peak direction. The capacity coded in HPMS is used for system planning analysis, not project level analysis. The number of peak lanes (number of through lanes used in the peak period in the peak direction) coded in HPMS (Item 87) is used in the procedures for determining capacity. The number of through lanes coded in HPMS (Item 34) is used in the procedures to determine the number of lanes on the facility. The equations for determining the volume/service flow ratio (V/SF) are shown at the end of this Appendix along with tables that contain the data items used in the capacity calculations and in the V/SF ratio.

All references to chapters, tables, etc., are to the HCM. All calculations and values in the Appendix are in English units; i.e., miles per hour (mph), feet, miles, etc. The assumptions made by FHWA for adjustment factors used in the procedures are consistent with the recommended values in the HCM. The reference to the data item value in the procedures indicates the way the data item is coded in the HPMS.

HIERARCHY OF APPLICATION FOR CAPACITY PROCEDURES

Figure 1 presents the decision rules for applying the methodologies of measuring capacity for highway sections. The logic is based on first identifying if the section is on a structure or is a rural unpaved road; and second if it is characterized by "interrupted flow;" that is, a section where traffic is influenced by traffic control devices (signals and stop signs).

If the traffic control device density is below the thresholds (0.5 signals or stop signs per mile), the facility is assumed to be an uninterrupted flow facility. For these, the following definitions apply.

Freeways (Urban and Rural)

For HPMS, the design characteristics, not the functional classification, determine if a section is a freeway ("freeway by design"). The characteristics of a freeway are:

- Four or more through lanes with two-way flow (Data Item 34 >= 4 and Data Item 27 = 2) **OR** two or more through lanes and one-way flow (Data Item 34 >= 2 and Data Item 27 = 1)
- Divided Cross-Section – for sections with two-way traffic flow, median width >= 4 feet (Data Item 57) or with a "positive" or "curbed" barrier (Data Item 56 = 1 or 2) (not applicable for one-way sections) and
- Full Control of Access (Data Item 55 = 1)

Multilane Highways (Urban and Rural)

The main characteristic distinguishing these facilities from freeways is the lack of access control. They are defined by:

- Partial or no access control (Data Item 55 = 2 or 3) with a Divided Cross-Section (see above under "Freeways") **OR** Full Access Control and Undivided Cross-Section; and
- 4 or more through lanes and two-way operation (Data Item 34 >= 4 and Data Item 27 = 2) **OR** 2 or more through lanes and one-way operation (Data Item 34 = 2 or 3 and Data Item 27 = 1)

Rural Two-Lane Highways
All rural sections that have two through lanes of travel and two-way operation are covered by this method. Most of these sections will not have full access control, though this condition does exist in the HPMS data.

Rural One-Lane, One-Way Highways
This is a rare condition in HPMS, but it does exist.

Rural Three-Lane Highways
These are highways with two through lanes in one direction and one through lane in the opposite direction.

Urban One/Two/Three-Lane Highways
These are highway sections in urban areas that do not meet the traffic control device density requirement for either signals or stop signs. They can either have one-way or two-way traffic flow, as follows:

- One-Way, One-Lane Highways: Data Item 34 = 1 and Data Item 27 = 1;
- Two-Way, 2/3-Lane Highways: Data Item 34 = (2 or 3) and Data Item 27 = 2; and
- Two-Way, One-Lane Highways: Data Item 34 = 2 and Data Item 27 = 1. This is an unusual occurrence but some states code unstriped highways in this manner. For HPMS, it is assumed that these are in fact two-lane highways.

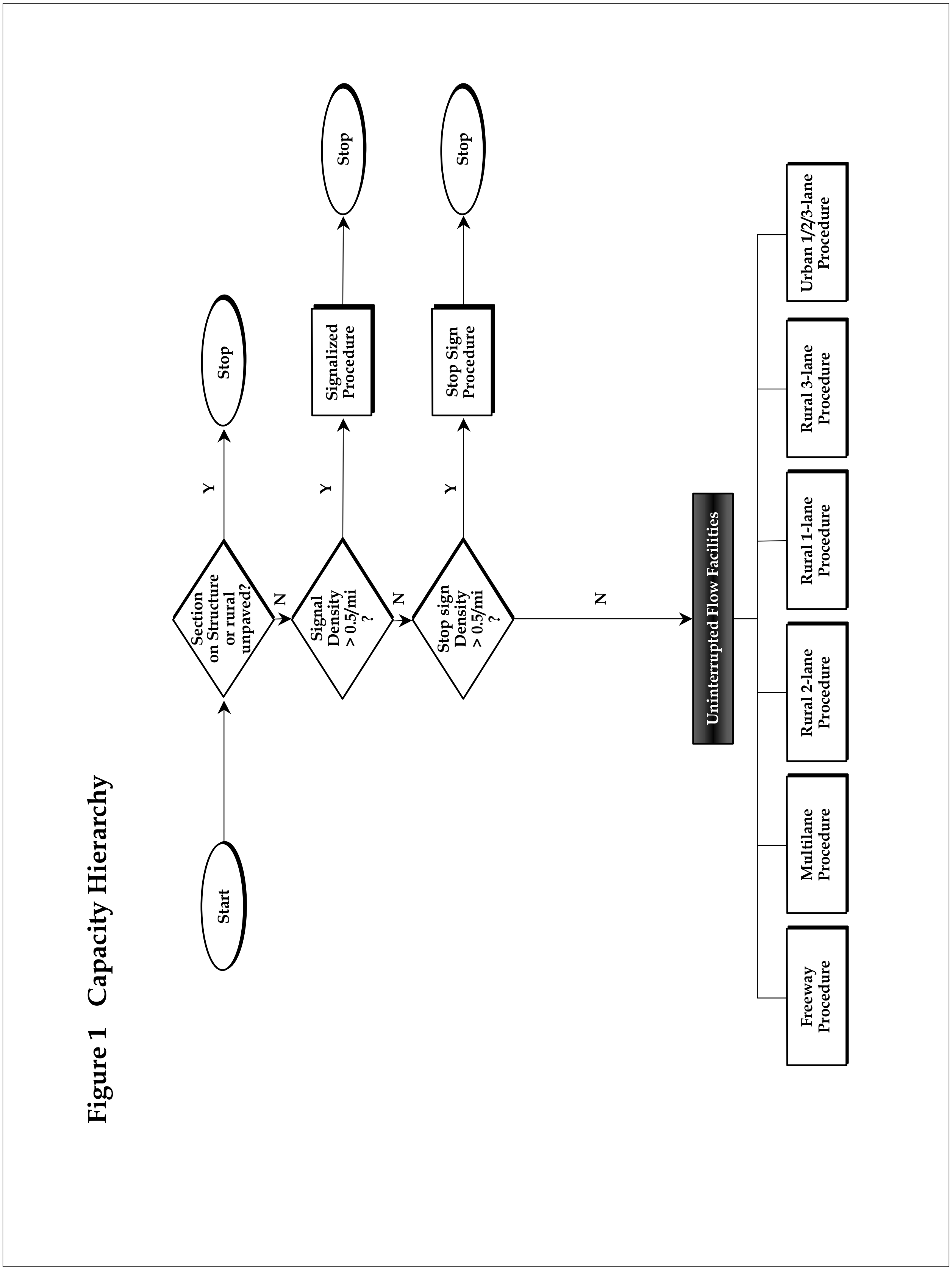


Figure 1. Capacity Hierarchy

FREEWAY CAPACITY

APPLICATION

All highways (rural and urban) that are "freeway by design" use the following procedures. These are facilities with:

- Four or more through lanes with two-way flow (Data Item 34 >= 4 and Data Item 27 = 2) **OR** two or more through lanes and one-way flow (Data Item 34 >= 2 and Data Item 27 = 1)
- Divided Highways – median width >= 4 feet (Data Item 57) or with a "positive" or "curbed" barrier (Data Item 56 = 1 or 2)
- Access-Controlled Highways (Data Item 55 = 1)

PROCEDURE

Step 1: Calculate Free Flow Speed (FFS)

The first step in the procedure is to estimate free flow speed (FFS) of the facility. *HCM* Equation 23-1 is applied directly:

$$FFS = BFFS - f_{LW} - f_{LC} - f_N - f_{ID} \qquad (1)$$

Where:

$BFFS$ = base free flow speed
f_{LW} = adjustment factor for lane width
f_{LC} = adjustment factor for right shoulder lateral clearance
f_N = adjustment factor for number of lanes
f_{ID} = adjustment factor for interchange density

Base Free Flow Speed

BFFS is set at 70 mph for urban facilities and 75 mph for rural facilities.

Adjustment Factor for Lane Width (f_{LW})

The values from *HCM* Exhibit 23-4 are used and are directly based on the values of Data Item 54:

Lane Width	Reduction in FFS (mph; f_{LW})
12 ft.	0.0
11 ft.	1.9
<=10 ft.	6.6

Adjustment Factor for Right Shoulder Lateral Clearance (f_{LC})

The values from *HCM* Exhibit 23-5 (shown as Table 1 here) are used and based directly on the values of Data Item 59. The number of lanes in one direction are computed by halving Data Item 34 for two-way facilities or by using Data Item 34 directly for one-way facilities:

Table 1. Influence of Right Shoulder Widths on FFS

Right Shoulder Width	Reduction in FFS (mph; f_{LC})			
	LANES IN ONE DIRECTION			
	2	3	4	>=5
>=6	0.0	0.0	0.0	0.0
5	0.6	0.4	0.2	0.1
4	1.2	0.8	0.4	0.2
3	1.8	1.2	0.6	0.3
2	2.4	1.6	0.8	0.4
1	3.0	2.0	1.0	0.5
0	3.6	2.4	1.2	0.6

Adjustment Factor for Number of Lanes (f_N)

The values from *HCM* Exhibit 23-6 are used and based on the number of lanes in one direction. For two-way operation, the number of lanes in one direction is Data Item 34 divided by 2; for one-way facilities the value of Data Item 34 is used directly. The adjustment is made for urban freeways only; for rural facilities f_N is set to 0:

No. Lanes (One Direction; Urban Only)	Reduction in FFS (mph; f_N)
>= 5	0.0
4	1.5
3	3.0
2	4.5

Adjustment Factor for Interchange Density (f_{ID})

The number of interchanges is no longer available in HPMS. Therefore, an analysis of 1998 HPMS data was done to determine average interchange densities as a function of functional class and area size (Data Item 13, Rural/Urban Designation). For rural sections, interchange density is assumed not to influence free flow speed. The factor is based on the average interchange densities, as found in the 1998 HPMS data, and linear interpolation of the information in *HCM* Exhibit 23-7.

Table 2. Influence of Interchange Density on FFS

Functional Class	Area Size	Interchange Density	Interchange Adj. Factor, (f_{ID})
Urban Interstates	Small Urban	0.70	1.0
	Small Urbanized	0.76	1.3
	Large Urbanized	0.83	1.7
Other Urban Highways Qualifying as Freeways	Small Urban	0.83	1.7
	Small Urbanized	0.88	1.9
	Large Urbanized	0.91	2.1

Step 2: Calculate Base Capacity (*BaseCap*)

The Base Capacity (passenger cars per hour per lane; pcphpl) of a freeway facility is based on information found in *HCM* Exhibit 23-3. The following equations were developed based on this information:

$$BaseCap = 1{,}700 + 10FFS;\ \text{for } FFS <= 70 \quad (2)$$

$$BaseCap = 2{,}400;\ \text{for } FFS > 70$$

Step 3: Determine Peak Capacity (*PeakCap*)

The *HCM 2000* procedure does not make adjustments to the Base Capacity in order to calculate level of service and performance measures. Instead, adjustments are made to the hourly demand volume. However, for HPMS, the capacity of the segment, in terms of total vehicles per hour (vph), must be computed for a variety of analytic purposes. Therefore, the same factors used in the *HCM 2000* to adjust volume are used to adjust base capacity instead. Essentially, these adjustments convert the units from passenger cars to vehicles and lower capacity to account for the effect of heavy vehicles. The procedure is based on *HCM* Equation 23-2:

$$PeakCap = BaseCap * PHF * N * f_{HV} * f_p \quad (3)$$

Where:

PeakCap = HPMS Peak Capacity (Data Item 95), vehicles per hour (all lanes, one direction)

PHF = Peak Hour Factor

N = Number of lanes in one direction

= Number of Peak Lanes (Data Item 87)

f_{HV} = Adjustment factor for heavy vehicles

f_p = Adjustment factor for driver population

Peak Hour Factor (PHF)

The Peak Hour Factor is used to account for variations in flow within the peak hour. The *HCM 2000* recommends defaults of 0.92 for urban facilities and 0.88 for rural facilities (Chapter 13). It also states that congested facilities have larger values (0.95 is "typical") than uncongested (unsaturated) ones. Clearly, these factors can have a large impact on capacity. However, determining if an HPMS section is congested is in fact a function of first determining its capacity. Therefore, an iterative process is used:

- Set PHF in Equation 3 equal to 1.0; compute peak capacity
- Determine an initial volume-to-capacity ratio (V/C), where:
  - V = AADT * K-Factor * D-Factor (Data Items 33, 85, and 86, respectively, where the K- and D-factors are expressed as decimals)
  - C = Peak Capacity
- Assign a final PHF as follows:

Table 3. PHF Assignment

Area Type	V/C Ratio	PHF
Rural	< 0.7744	0.88
	0.7744<=V/C<=0.9025	Equation (4)
	> 0.9025	0.95
Urban	< 0.8100	0.90
	0.8100<=V/C<=0.9025	Equation (4)
	> 0.9025	0.95

Where: $PHF = (0.9025 * V/C)^{0.5}/0.95$ for special cases above (4)

Adjustment Factor for Heavy Vehicles (f_{HV})

The adjustment factor for heavy vehicles is based on calculating passenger-car equivalents for trucks and buses. (Recreational vehicles are ignored.) *HCM* Equation 23-3 and Exhibit 23-8 are used:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \quad (5)$$

Where:

P_T = Proportion of trucks and buses in the traffic stream, expressed as a decimal (e.g., 0.15 for 15%)

= (Percent Peak Combination Trucks, Data Item 83 + Percent Peak Single Unit Trucks, Data Item 81)

E_T = Passenger-car equivalents

= 1.5 for all urban freeways

= 1.5 for rural freeways in level terrain (Data Item 70 = 1)

= 2.5 for rural freeways in rolling terrain (Data Item 70 = 2)

= 4.5 for rural freeways in mountainous terrain (Data Item 70 = 3)

Adjustment Factor for Driver Population (f_p)

For Urban Freeways, the driver population factor is set to 1.0 to indicate that drivers are familiar with roadway and traffic conditions (by virtue of the fact that most of the traffic is composed of commuters). On Rural Freeways, the factor is set to 0.975.

MULTILANE HIGHWAY CAPACITY

APPLICATION

The following procedures are applied to rural and urban multilane highways with the following characteristics:

- Partial or no access control (Data Item 55 = 2 or 3) with a Divided Cross-Section (see above under "Freeways") **OR** Full Access Control and Undivided Cross-Section; and
- 4 or more through lanes and two-way operation (Data Item 34 >= 4 and Data Item 27 = 2) **OR** 2-3 through lanes and one-way operation (Data Item 34 = 2 or 3 and Data Item 27 = 1.

PROCEDURE

Step 1: Calculate Free Flow Speed (FFS)

The first step in the procedure is to estimate free flow speed (FFS) of the facility. *HCM* Equation 21-1 is applied directly:

$$FFS = BFFS - f_{LW} - f_{LC} - f_M - f_A \quad (6)$$

Where:

$BFFS$ = base free flow speed

f_{LW} = adjustment factor for lane width

f_{LC} = adjustment factor for lateral clearance

f_M = adjustment factor for median type

f_A = adjustment factor for access points

Base Free Flow Speed

Base Free Flow Speed is based on the coded speed limit (Data Item 80) and guidance from the *HCM 2000*. To be consistent with the *HCM 2000* methodology, the BFFS is not allowed to go below 40 mph or above 70 mph. This conflicts with guidance in the *HCM 2000* which states that the methodology is valid for free flow speeds between 45 mph and 60 mph. However, the *HCM 2000* methodology is geared to estimating performance characteristics, not capacity; for the purpose of capacity, these restrictions were relaxed.

$BFFS$ = 40 mph, for posted speed limits < 40 mph (7)

= $SpeedLimit$ + 7, for posted speed limits 40-45 mph

= $SpeedLimit$ + 5, for posted speed limits >= 50 mph

Where: *SpeedLimit* is the value for Data Item 80.

Adjustment Factor for Lane Width (f_{LW})

The values from *HCM* Exhibit 21-4 are used and directly based on the values of Data Item 54:

Lane Width	Reduction in *FFS* (mph; f_{LW})
12 ft.	0.0
11 ft.	1.9
<=10 ft.	6.6

Adjustment Factor for Lateral Clearance (f_{LC})

The values from *HCM* Exhibit 21-5 are used and based on computing Total Lateral Clearance (*TLC*) using right and left shoulder widths. Lateral Clearance Left (LC_L) is computed for divided highways only (Data Item 57 >= 4 or Data Item 56 = 1 or Data Item 56 = 2). In all other cases, such as if a continuous two-way left turn lane exists (Data Item 88 = 2) or the facility is undivided, then LC_L is set to 6. (The median type adjustment factor accounts for the fact that the roadway is undivided.) Facilities with one-way traffic operation are considered divided highways since there is no opposing flow to interfere with traffic. For one-way facilities, left shoulder width is not coded. Therefore, a value of 6 is assumed for one-way facilities.

$$TLC = LC_R + LC_L \quad (8)$$

Where:

LC_R = Data Item 59, maximum value of 6

LC_L = Data Item 60, maximum value of 6

Once *TLC* is computed, the values in *HCM* Exhibit 21-5 are used. Linear interpolation is used for intermediate values:

Table 4. Adjustment for Lateral Clearance

4-Lane Two-Way Highways and 2-Lane One-way Highways		6+Lane Two-Way Highways and 3+Lane One-Way Highways	
Total Lateral Clearance	**Reduction in *FFS***	**Total Lateral Clearance**	**Reduction in *FFS***
12	0.0	12	0.0
10	0.4	10	0.4
8	0.9	8	0.9
6	1.3	6	1.3
4	1.8	4	1.7
2	3.6	2	2.8
0	5.4	0	3.9

Adjustment Factor for Median Type (f_M)

The values from *HCM* Exhibit 21-6 are used and based on whether the facility is divided or undivided. (See definition under Lateral Clearance Adjustment).

Highway Type	Reduction in FFS (mph; f_M)
Undivided	1.6
Divided (including TWLTLs[1])	0.0

Adjustment Factor for Access Points (f_A)

The number of access points per mile is based directly on the values of the number of at-grade intersections with no traffic control devices (Data Item 94) and section length (Data Item 30). In addition, default values for driveways per mile are also assumed. A linear equation was fit to the data in *HCM* Exhibit 21-7 and produces:

$$f_A = \text{MIN}((0.25 * AccessPointDensity), 10) \quad (9)$$

Where:

AccessPointDensity = (Data Item 94/Data Item 30) + *DrivewayDensity*

DrivewayDensity = 2 for divided highways

= 3 for undivided highways

[1] Two-Way Left Turning Lanes.

Step 2: Calculate Base Capacity (BaseCap)

The Base Capacity (passenger cars per hour per lane; pcphpl) of a multilane facility is based on information found in *HCM* Exhibit 21-3. The following equations were developed based on this information:

$$BaseCap = 1{,}000 + 20FFS; \text{ for } FFS <= 60 \quad (10)$$

$$BaseCap = 2{,}200; \text{ for } FFS > 60$$

Step 3: Determine Peak Capacity (PeakCap)

The *HCM 2000* procedure does not make adjustments to the Base Capacity in order to calculate level of service and performance measures. Instead, adjustments are made to the hourly demand volume. However, for HPMS, the capacity of the section, in terms of total vehicles per hour (vph), must be computed for a variety of analytic purposes. Therefore, the same factors used in the *HCM 2000* to adjust volume are used to adjust base capacity. Essentially, these adjustments convert the units from passenger cars to vehicles and lower capacity to account for the effect of heavy vehicles. The procedure is based on *HCM* Equation 21-3:

$$PeakCap = BaseCap * PHF * N * f_{HV} * f_p \quad (11)$$

Where:

$PeakCap$	=	HPMS Peak Capacity (Data Item 95), vehicles per hour (all lanes, one direction)
PHF	=	Peak Hour Factor
N	=	Number of lanes in one direction
	=	Number of Peak Lanes (Data Item 87)
f_{HV}	=	Adjustment factor for heavy vehicles
f_p	=	Adjustment factor for driver population
	=	1.0 for HPMS

Peak Hour Factor (*PHF*)

The Peak Hour Factor is used to account for variations in flow within the peak hour. The *HCM 2000* recommends defaults of 0.92 for urban facilities and 0.88 for rural facilities (Chapter 13). It also states that congested facilities have larger values (0.95 is "typical") than uncongested (unsaturated) ones. Clearly, these factors can have a large impact on capacity. However, determining if an HPMS section is congested is in fact a function of first determining its capacity. Therefore, an iterative process is used:

- Set *PHF* in Equation 6 equal to 1.0; compute peak capacity
- Determine an initial volume-to-capacity ratio (V/C), where:
  - V = AADT * K-Factor * D-Factor (Data Items 33, 85, and 86, respectively)
  - C = Peak Capacity
- Assign a final *PHF* as follows:

Table 5. Final *PHF* Assignment

Area Type	V/C Ratio	PHF
Rural	< 0.7744	0.88
	0.7744<=V/C<=0.9025	Equation (12)
	> 0.9025	0.95
Urban	< 0.8100	0.90
	0.8100<=V/C<=0.9025	Equation (12)
	> 0.9025	0.95

Where: $PHF = (0.9025 * V/C)^{0.5}/0.95$ for special cases above (12)

Adjustment Factor for Heavy Vehicles (f_{HV})

The adjustment factor for heavy vehicles is based on calculating passenger-car equivalents for trucks and buses. (Recreational vehicles are ignored.) *HCM* Equation 23-3 and Exhibit 23-8 are used:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \qquad (13)$$

Where:

P_T = Proportion of trucks and buses in the traffic stream, expressed as a decimal (e.g., 0.15 for 15%)

= (Percent Peak Combination Trucks {Data Item 83}) + (Percent Peak Single Unit Trucks {Data Item 81})

E_T = Passenger-car equivalents

= 1.5 for all urban highways

= 1.5 for rural highways in level terrain (Data Item 70 = 1)

= 2.5 for rural highways in rolling terrain (Data Item 70 = 2)

= 4.5 for rural highways in mountainous terrain (Data Item 70 = 3)

RURAL TWO-LANE CAPACITY

BASIC CONCEPTS AND APPROACH

In the *HCM 2000*, capacity is taken as a value that "… is nearly independent of the directional distribution of traffic on a facility, except that for extended lengths of a two-lane highway, the capacity will not exceed 3,200 pc/h for both directions of travel combined." The purpose of the *HCM 2000* procedure is to develop two primary performance measures: average travel speed (ATS) and percent time-spent-following. In computing the ATS, v/c ratio, or other performance measures, adjustments are made to volume while the capacity remains fixed at 3,200 passenger cars per hour (pch).

For HPMS, the procedure for estimating ATS is the better of the two for estimating capacity. Equation 20-5 in the *HCM 2000* relates ATS to FFS, adjusted flow rate, and the no passing zone factor:

$$ATS = FFS - 0.00776V_P - f_{np} \quad (14)$$

Where:

ATS	=	Average travel speed
V_P	=	passenger car equivalent flow rate for peak 15-minutes
f_{np}	=	no passing zone adjustment factor from Table 20-11

FFS is developed from a base (ideal) free flow speed and a flow speed adjusted for lane width, shoulder width, and access points. V_p is the two-way hourly volume adjusted for peak 15-minute flows, grades, and heavy vehicles. These concepts are different from previous versions of the *HCM* where adjustments were made to capacity. However, for use in HPMS and its applications, estimates of capacity are needed. Therefore, the procedure used here is based on adjusting the base capacity for the factors related to V_P and f_{np}. The adjustments for *FFS* are **not** applied to capacity. This avoids double counting when speed and delay methodologies other than those in the *HCM 2000* are applied. (These methods usually relate performance measures directly to volume and capacity.)

APPLICATION

All rural sections that have partial or no access control and two through lanes of travel and two-way operation are covered by this method.

PROCEDURE

For HPMS purposes estimates of capacity are still needed. Therefore, instead of adjusting flow rates, (volumes) capacity will be adjusted by most of the same factors:

$$\text{Two-Way Capacity} = (3{,}200\ pch * PHF * f_G * f_{HV}) - V_{NP} \quad (15)$$

Where:

PHF	=	Peak Hour Factor
	=	0.88
f_G	=	Adjustment factor for grades
f_{HV}	=	Adjustment factor for heavy vehicles
V_{NP}	=	Volume adjustment for no passing zones

Grade Adjustment Factor (f_G)

HCM Exhibit 20-7 offers values for f_G but only for level and rolling terrain; it is assumed that the steep grades associated with mountainous terrain will be analyzed individually. For HPMS, this is impractical since a section can have multiple grades: determining an average grade may underestimate the impact while selecting the most severe grade may overestimate the impact. As a compromise, f_G values for grades in the 5.5 – 6.5 percent range with a length of 0.5 miles are assumed for mountainous terrain and *HCM* Exhibit 20-13 is used. This results in the factors presented in Table 6. The two-way flow rates in Table 6 are based on adjusting the HPMS AADT value to peak passenger cars and is computed as:

$$\text{Two-Way Flow Rate} = (AADT * K)/f_{HVD} \quad (16)$$

Where:

$AADT$	=	Data Item 33
K	=	Data Item 85, expressed as a decimal
f_{HVD}	=	Daily heavy vehicle adjustment factor
	=	$1/(1 + 0.5P_T)$
P_T	=	Percentage of daily trucks
	=	(Data Item 82 + Data Item 84) * 0.01

Table 6. Grade Adjustment Factors (f_G) for HPMS

Two-Way Flow Rates			
(PCH)	LEVEL	ROLLING	MOUNTAINOUS
0-600	1.00	0.71	0.57
>600-1,200	1.00	0.93	0.85
>1,200	1.00	0.99	0.99

Adjustment for Heavy Vehicles (f_{HV})

The *HCM 2000* presents two ways of computing passenger car equivalents (pce's) for heavy trucks: one for computing ATS and one for computing percent time-spent-following. For capacity purposes, ATS is considered to be more appropriate. (Percent time-spent-following is more descriptive of driver experience than of physical capacity.) As with grades, mountainous sections are excluded from the default values in the *HCM 2000*. Therefore, for default purposes, pce's for trucks (E_T) is also taken for grades of 5.5 – 6.5 percent and a length of 0.5 miles using *HCM* Exhibit 20-15. This results in the values in Table 7.

Table 7. Passenger Car Equivalents for Trucks (E_T)

Two-Way Flow Rates	Type of Terrain		
(PCH)	LEVEL	ROLLING	MOUNTAINOUS
0-600	1.7	2.5	7.2
>600-1,200	1.2	1.9	7.2
>1,200	1.1	1.5	7.2

Once E_T is found, the adjustment factor for heavy vehicles is computed as:

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1)} \qquad (17)$$

Where:

P_T = proportion of trucks (combinations plus single units) from HPMS, expressed as a decimal
= (Percent Peak Combination Trucks, Data Item 83 + Percent Peak Single Unit Trucks, Data Item 81)

E_T = Passenger car equivalents from Table 7.

Note that recreational vehicles are included with single unit trucks in HPMS.

Peak Hour Factor (*PHF*)

The *PHF* represents the variation in traffic flow within an hour. A default value of 0.88 should be used for rural two-lane highways.

Adjustment for Percentage of No-Passing Zones (V_{NP})

This adjustment is used in the *HCM 2000* procedure to compute ATS rather than adjusting flow rate. In Equation 1, f_{np} can be equilibrated to volume simply by dividing by 0.00776. For example, an f_{np} of 2.0 translates to 258 passenger cars. For HPMS, this adjustment can also be made to capacity since it too is in terms of passenger cars:

$$V_{NP} = f_{NP}/0.00776 \quad (18)$$

Where:

f_{NP} = values from *HCM* Exhibit 20-11 (given here as Table 8)

HCM Exhibit 20-11 should be entered using values for Two-Way Flow Rate (Equation 18). *HCM* Exhibit 20-11 also requires "% No Passing Zones". This computes as:

% No Passing Zones = 1 – (Data Item 78 * 0.01) (19)

Table 8. Adjustment (f_{np}) for Effect of No-Passing Zones on Average Travel Speed on Two-Way Segments

TWO-WAY DEMAND FLOW RATE, VP(PC/H)	Reduction in Average Travel Speed (mi/h) No-Passing Zones (%)										
	0	10	20	30	40	50	60	70	80	90	100
0-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
101-300	0.0	0.3	0.6	1.0	1.4	1.9	2.4	2.5	2.6	3.1	3.5
301-500	0.0	0.9	1.7	2.2	2.7	3.1	3.5	3.7	3.9	4.2	4.5
501-700	0.0	0.8	1.6	2.0	2.4	2.7	3.0	3.2	3.4	3.7	3.9
701-900	0.0	0.7	1.4	1.7	1.9	2.2	2.4	2.6	2.7	2.9	3.0
901-1,100	0.0	0.6	1.1	1.4	1.6	1.8	2.0	2.1	2.2	2.4	2.6
1,101-1,300	0.0	0.4	0.8	1.0	1.2	1.4	1.6	1.8	1.9	2.0	2.1
1,301-1,500	0.0	0.3	0.6	0.8	0.9	1.1	1.2	1.3	1.4	1.6	1.7
1,501-1,700	0.0	0.3	0.6	0.7	0.8	1.0	1.1	1.2	1.3	1.4	1.5
1,701-1,900	0.0	0.3	0.5	0.6	0.7	0.9	1.0	1.1	1.1	1.2	1.3
1,901-2,100	0.0	0.3	0.5	0.6	0.6	0.8	0.9	1.0	1.0	1.1	1.1
2,101-2,300	0.0	0.3	0.5	0.6	0.6	0.8	0.9	0.9	0.9	1.0	1.1
2,301-2,500	0.0	0.3	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.1
2,501-2,700	0.0	0.3	0.5	0.6	0.6	0.7	0.8	0.9	0.9	1.0	1.0
2,701-2,900	0.0	0.3	0.5	0.6	0.6	0.7	0.7	0.8	0.8	0.9	0.9
2,901-3,100	0.0	0.3	0.5	0.6	0.6	0.7	0.7	0.7	0.7	0.8	0.8
3,101-3,300	0.0	0.3	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.7	0.7
>3,300	0.0	0.3	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5

Adapted from *HCM* Exhibit 20-11.

RURAL ONE-LANE CAPACITY

APPLICATION

These highways, though rare, do exist in HPMS. They include facilities with both one-way and two-way operation.

PROCEDURE

One-Way Operation

The capacity of these sections should be computed using the procedure for Rural Two-Lane Highways, with the following changes:

- Change the base capacity from 3,200 pch to 1,600 pch
- Compute the one-way flow rate using the same equation as for two-way flow rate; enter all lookup tables and equations labeled for two-way flow rate with this value.
- Assume 100% no passing zones.

The resulting capacity is, by definition, a one-way value.

Two-Way Operation

One-lane highways open to both directions of traffic are extremely rare. For these cases, compute the capacity for one-way operation and divide by 2.

RURAL THREE-LANE HIGHWAY CAPACITY

APPLICATION

These highways have two through lanes in one direction and a single lane in the opposite direction. The through lanes are assumed to cover an extended length and are not auxiliary or truck climbing lanes. (This is consistent with the coding of HPMS data).

PROCEDURE

It is assumed that these highways operate as a multilane undivided facility in the two-lane direction and as a single direction of a rural two-lane facility in the one-lane direction. The two-way capacity (required by HPMS for these facilities) is then the sum of these two separate capacities.

The capacity for the two-lane direction is computed using the Multilane Highway capacity procedure assuming an undivided cross-section. The capacity for the one-lane direction is computed using the procedure for Rural One-Lane, One-Way Highways.

SIGNALIZED INTERSECTION CAPACITY

APPLICATION

Sections that meet the criteria in the hierarchy for signalized intersection density (> .5 /mile) are analyzed using this procedure. For both rural and urban section where Left Turning Lanes (Data Item 88) and Right Turning Lanes (Data Item 89) are missing, a simplified procedure is used (see page N-23). Data Items 88 and 89 are used to identify lane groups, a critical step in the signalized intersection capacity procedure.

Typical Percent Green Time (Data Item 91) and Peak Parking (Data Item 61) are considered optional for the coding of rural sections. However, default values for these data are provided so that if Data Items 88 and 89 are present, the urban procedure may be used.

URBAN PROCEDURE

Signalized Intersection Approach Capacity

For HPMS, the capacity of the entire approach is required, including all movements, primarily for consistency with the speed/delay procedures. Intersection approach capacity is based on *HCM* Equation 16-6:

$$C_A = \sum_i s_i \frac{g_i}{C} \qquad (20)$$

where:

C_A	=	intersection approach capacity
s_i	=	saturation flow rate for lane group i
$\frac{g_i}{C}$	=	effective green ratio for lane group i

This approach is based directly on the *HCM 2000* principles. When operational analysis is conducted using capacity computed in this way, the *HCM 2000* method takes into account the volumes assigned to each lane group. In HPMS, turning movement volumes are not available; only total intersection approach volume is computed from AADT. Therefore, the volume-to-service flow ratio for HPMS is computed using the total intersection approach capacity and volume, rather than considering the operational characteristics of each lane group individually. The HPMS method therefore assumes that traffic is distributed roughly proportionate to the available lane group capacity (i.e., lane groups are neither under-utilized nor over-utilized). While it is possible that this may result in an overestimation of capacity in some instances, there is currently no basis upon which a realistic adjustment can be made. Further, because lane groups are based on the existence of exclusive turning lanes, there is no reason to suspect some lane groups are underutilized at the expense of others; turning lanes are implemented to handle high turning volumes.

Determining Lane Groups

The *HCM 2000* methodology for signalized intersections is based on determining capacity for individual lane groups. Lane groups take into account intersection geometry and turning movements. Separate lane groups should be identified for:

- Continuous LT lane or 1 + exclusive LT lanes – LT only lane group
- Continuous RT lane or 1 + exclusive RT lanes – RT only lane group

In addition to possible exclusive turning lane groups, it is always assumed that through movements occur at the intersection. This assumption does not account for T-intersections, but no intersection geometry data exist in HPMS that would allow this determination. The maximum number of lane groups for HPMS purposes is three. Table 9 is used in developing lane groups, based on the coding of left and right turning lanes.

Table 9. Determining Lane Groups in HPMS

DATA ITEM 88	DATA ITEM 89	NO. PEAK LANES	LANE GROUPS	NO. LANES IN GROUP
1	1	N/A	Exclusive LT Exclusive Through Exclusive RT	2 *N* 2
	2, 3		Exclusive LT Exclusive Through Exclusive RT	2 *N* 1
	4	1, 2	Exclusive LT Shared Through/RT	2 *N*
		3+	Exclusive LT Exclusive Through Shared Through/RT	2 *N*- 1 1
	5	N/A	Exclusive LT Exclusive Through	2 *N*
2,3	1	N/A	Exclusive LT Exclusive Through Exclusive RT	1 *N* 2
	2, 3		Exclusive LT Exclusive Through Exclusive RT	1 *N* 1
	4	1, 2	Exclusive LT Shared Through/RT	1 *N*
		3+	Exclusive LT Exclusive Through Shared Through/RT	1 *N*- 1 1
	5	N/A	Exclusive LT Exclusive Through	1 *N*
4	1	1, 2	Shared LT/Through Exclusive RT	Data Item 87 2
		3+	Shared LT/Through Exclusive Through Exclusive RT	1 *N*– 1 2
	2, 3	1, 2	Shared LT/Through Exclusive RT	*N* 1
		3+	Shared LT/Through Exclusive Through Exclusive RT	1 *N*– 1 1
	4	1, 2	Shared LT/Through/RT	*N*
		3+	Shared LT/Through Exclusive Through Shared RT/Through	1 *N*– 2 1
	5	1, 2	Shared LT/Through	*N*
		3+	Shared LT/Through Exclusive Through	1 *N*– 1
5	1	N/A	Exclusive Through Exclusive RT	*N* 2
	2, 3	N/A	Exclusive Through Exclusive RT	*N* 1
	4	1, 2	Shared RT/Through	*N*
		3+	Shared RT/Through Exclusive Through	1 *N*– 1
	5	N/A	Exclusive Through	*N*

Where: *N* = Data Item 87

Determining Saturation Flow Rate

A slightly modified version of *HCM* Equation 16-4 is used to determine saturation flow rate:

$$s = s_o N f_w f_{HV} f_g f_p f_{bb} f_a f_{LU} f_{LT} f_{RT} f_{Lpb} f_{Rpb} PHF \qquad (21)$$

where:

$s =$	saturation flow rate for subject lane group, expressed as a total for all lanes in lane group (vph);
$s_o =$	base saturation flow rate per lane (pcphpl);
$N =$	number of lanes in lane group;
$f_w =$	adjustment factor for lane width;
$f_{HV} =$	adjustment factor for heavy vehicles in traffic stream;
$f_g =$	adjustment factor for approach grade;
$f_p =$	adjustment factor for existence of a parking lane and parking activity adjacent to lane group;
$f_{bb} =$	adjustment factor for blocking effect of local buses that stop within intersection area;
$f_a =$	adjustment factor for area type;
$f_{LU} =$	adjustment factor for lane utilization;
$f_{LT} =$	adjustment factor for left turns in lane group;
$f_{RT} =$	adjustment factor for right turns in lane group;
$f_{Lpb} =$	pedestrian-bicycle adjustment factor for left-turn movements;
$f_{Rpb} =$	pedestrian-bicycle adjustment factor for right-turn movements; and
$PHF =$	Peak Hour Factor.

Note that the Peak Hour Factor is included in the calculation of saturation flow rate. The *HCM 2000* adjusts volume with this factor, but for HPMS purposes, it is used to adjust saturation flow rate.

Base Saturation Flow Rate, S_O

The base saturation flow rate is set at 1,900 pcphpl.

Adjustment Factor for Lane Width, f_W

The lane width adjustment factor is based directly on the *HCM 2000* procedure:

$$f_W = 1 + \frac{(W - 12)}{30} \qquad (22)$$

where:

W = Lane Width (Data Item 54); minimum of 8, maximum of 16

Adjustment for Heavy Vehicles, f_{HV}

The heavy vehicle adjustment factor is based directly on the *HCM 2000* procedure, assuming 2 passenger car equivalents for heavy vehicles:

$$f_{HV} = \frac{100}{100 + HV(E_T - 1)} \tag{23}$$

where:

HV = percent heavy vehicles

E_T = 2.0 passenger car equivalents

The percent heavy vehicles factor is the sum of peak combination and single unit trucks (Data Items 81 and 83).

Adjustment for Grade, f_g

For HPMS purposes, f_g is set to 1.0 because of the lack of grade information on urban minor arterials and collectors.

Adjustment for Parking, f_p

The calculation of the parking adjustment factor is:

$$f_p = \frac{N - 0.1 - \frac{18N_m}{3{,}600}}{N} \tag{24}$$

where:

f_p = parking adjustment factor

N = number of lanes in group

N_m = number of parking maneuvers per hour

= 6 for two-way streets with parking one side

= 12 for two-way streets with parking both sides or one-way streets with parking one side

= 24 for one-way streets with parking on both sides (based on *HCM* Exhibit 10-20).

The parking factor is applied only to lane groups that are immediately adjacent to parking spaces. For two-way streets or one-way streets with parking on one side, this is assumed to occur in the right-most lane group; this will be either an exclusive right-turn lane or a lane with shared movements. For one-way streets with parking on both sides, the parking factor adjustment is made for the left-most **and** the right-most lane groups.

When parking is not allowed or unavailable (Data Item 61 = 3), f_p is set to 1.0. It is also set to 1.0 if Data Item 61 = 0.

Adjustment for Bus Blockage, f_{bb}

For HPMS, f_{bb} is set to 1.0. No data exist in HPMS as to the occurrence of bus routes. Further, the default values in the *HCM 2000* for bus maneuvers lead to adjustment factors close to 1.0.

Type of Area Adjustment, f_a

Area type is no longer coded in HPMS. An analysis of 1998 HPMS showed that 9 percent of urban signalized intersections were located in CBDs. The *HCM 2000* indicates that f_a should be 0.9 in CBDs, 1.0 elsewhere. Weighting these values with the findings from the 1998 HPMS data provides a value of 0.991 for f_a for urban conditions. A value of 1.0 is used for rural conditions.

Lane Utilization Adjustment, f_{LU}

The *HCM 2000* states that: "As demand approaches capacity, the analyst may use lane utilization factors [close] to 1.0, which would indicate a more uniform use of the available lanes and less opportunity for drivers to freely select their lane" (*HCM* page 10-26). Because the purpose of this factor in HPMS is to estimate capacity rather than perform an analysis of an individual intersection, a lane utilization adjustment factor of 1.0 is used. This will avoid underestimating capacity in investment analysis where demand volumes are forecast for a long time horizon (usually 20 years).

Adjustment for Left Turns, f_{LT}

Left turns are a major determinant of intersection approach capacity, yet only limited data are available in HPMS for conducting capacity analyses. The *HCM 2000* identifies six cases, as shown in Table 10. The adjustment factor for left turns is applied only if left turns are made from the lane group; this determination is made by checking the coding of Data Item 88, also as shown in Table 10.

Table 10. *HCM 2000* Left Turn Adjustment Cases as Applied to HPMS

LT Adjustment Case	Data Item 88	Functional Class	f_{LT}
1. Protected Phasing, Exclusive LT	1, 2, 3	All Arterials; Rural Major Collectors	$f_{LT} = 0.95$
2. Permitted Phasing, Exclusive LT	1, 2, 3	Rural Minor Collectors; Urban Collectors	(see below)
3. Protected/Permitted Phasing, Exclusive LT	N/A	N/A	N/A
4. Protected Phasing, Shared LT	4	Principal Arterials	$f_{LT} = \frac{1}{1.0 + 0.05P_{LT}}$ ($P_{LT} = 0.10$)
5. Permitted Phasing, Shared LT	4	Minor Arterials; All Collectors	(see below)
6. Protected/Permitted Phasing, Shared LT	N/A	N/A	N/A

A major assumption here is that the phasing is determined by functional class; higher order facilities are assumed to have protected phasing.

Note that Protected/Permitted Phasing is assumed to not exist because of lack of information on signal phasing in HPMS. For Case 4, P_{LT} is the proportion of left turns in the lane group. As recommended in the *HCM 2000*, a default value of 10 percent is used for HPMS (*HCM* page 10-19).

If left turns are not made from the lane group, the left turn adjustment factor is set to 1.0.

Special Procedure for Permissive Left Turns

The permissive left turn procedure in the *HCM 2000* is highly complex and dependent on many variables not present in the HPMS data (Appendix C, *HCM* Chapter 16). The new procedure is substantially more complex than those in previous versions of the *HCM*. For HPMS purposes, the procedure from the 1994 edition of the *HCM* is used because it is more compatible with the available data in HPMS:

$$f_{LT} = (1400-V_o)/[(1400-V_o)+(235+0.435*V_o)*P_{LT}] \text{ for } V_o <= 1{,}220 \text{ vph} \quad (25)$$

$$= 1/(1+(4.525*P_{LT})) \text{ for } V_o > 1{,}220 \text{ vph}$$

Where: V_o = AADT * K * (1 – D); this is the opposing flow in the off peak direction

AADT = annual average daily traffic, (Data Item 33)

K = K-factor, (Data Item 85) expressed as a decimal

D = the directional factor for the peak direction, (Data Item 86) expressed as a decimal

P_{LT} = proportion of left turns; assume proportion of left turns is 10 percent

Adjustment for Right Turns, f_{RT}

The adjustment factor for right turns is applied only if right turns are made from the lane group. The right turn adjustment factor is based on the coding of HPMS Data Item 89 as follows:

$$f_{RT} = 0.85 \text{ (for Data Item 89 = 1, 2, or 3)} \quad (26)$$

$$= 1.0 - 0.15P_{RT} \text{ (for Data Item 89 = 4)}$$

where:

$$P_{RT} = \text{proportion of right turns in the lane group}$$
$$= 0.10 \text{ (HCM, page 10 - 19)}$$

If right turns are not made from the lane group, the right turn adjustment factor is set to 1.0.

Adjustment for Pedestrian-Bicycle Blockage on Left Turns, f_{Lpb}

As with permissive left turns, calculation of the adjustment factor for pedestrians and bicycles is complex and requires extensive inputs, most of which are unavailable in HPMS. Further, pedestrian/bicycle blockage is likely to have a major impact only in densely developed areas and these conditions can no longer be determined from HPMS data. Therefore, for the purpose of HPMS, f_{Lpb} is set to 1.0.

Adjustment for Pedestrian-Bicycle Blockage on Right-Turns, f_{Rpb}

Based on the same conditions as for pedestrian-bicycle blockage on left turns, f_{Rpb} is set to 1.0.

Peak Hour Factor (*PHF*)

As discussed on *HCM* page 10-8, a default value of 0.92 is used for the PHF for urban sections. For rural sections, the PHF is set to 0.88.

Effective Green Ratios (g_i/C) for Lane Groups

The following values are used for the various types of lane groups. They are based on the coded value for HPMS Data Item 91 (Typical Peak Percent Green Time), which applies to the through movement only. For all lane groups except for exclusive left turn lane groups, the value for Data Item 91 is used for g_i/C. (This assumes that an exclusive signal phase for right turns coincides with the through movement phase.) For Exclusive Left Turn Lane Groups, the green ratio is a function of the green ratio for the through movement (Data Item 91). A distinction is made for low and high values for through green ratio:

For g/C <= 0.65

$$g_{LT}/C = 0.35*g/C \quad \text{for principal arterials} \tag{27}$$

$$= 0.25*g/C \quad \text{for all other highway types}$$

For g/C > 0.65

$$g_{LT}/C = 0.5*(1 - g/C) \quad \text{(all highways)} \tag{28}$$

where: g/C = green ratio for through movement (Data Item 91).

If Data Item 91 is missing, g/C default values of 0.45 for arterials and 0.40 for collectors are used (*NCHRP 387*, Table 9-3).

Simplified Procedure For Rural Signalized Intersection Capacity And Urban Sections With Missing Data

Application

In the coding of HPMS data, several data items required for applying the urban signalized capacity analysis are either "optional" or not required for rural sections. The data items of interest for capacity calculations, since they are used to identify lane groups, are:

- Data Item 88: Left Turning Lanes
- Data Item 89: Right Turning Lanes.

Procedure

Although some states do code these items for rural sections, a provision must be made to handle cases where the data are not present; this could also be true for some urban sections. In the cases where rural signalized sections have nonzero values coded for these data items, the signalized intersection capacity is used. When these data are coded as zero, the following procedure is used:

$$C_A = 1{,}900 * N * f_w * f_{HV} * PHF * g/C \tag{29}$$

where:

C_A = intersection approach capacity

N	=	number of lanes on the segment (one direction)
	=	Data Item 87 (Number of Peak Lanes)
f_w	=	adjustment factor for lane width (use Equation 22)
f_{HV}	=	adjustment factor for heavy vehicles (use Equation 23)
PHF	=	Peak Hour Factor
	=	0.88 for rural conditions, 0.92 for urban conditions
g/C	=	effective green time-to-cycle length ratio
	=	0.55 for principal arterials
	=	0.45 for minor arterials
	=	0.40 for collectors

The *g/C* ratio default values given above attempt to account for, in a general way, the presence of exclusive turn lanes and phases. These values are higher than the default values listed in Table 9-3 of *NCHRP 387* (0.40-0.45) but those values consider only through movement capacity.

STOP SIGN-CONTROLLED HIGHWAY CAPACITY

APPLICATION

All highways that have at least one stop sign and meet the density requirement (> .5/mile) on the inventory route.

PROCEDURE

The *HCM 2000* procedure for stop sign-controlled intersections is complex and highly dependent on turning movements on all the approaches. Procedures also vary for two-way controlled intersections versus all-way controlled intersections. None of these data are present in HPMS. Therefore, a highly simplified method is recommended. It is based on the *HCM 2000* procedure for two-way controlled intersections. This is the simpler and less data intensive of the two methods.

The procedure is based on first calculating the potential capacity for each turning movement. (It is assumed that the potential capacity is equal to the "movement capacity", and none of the *HCM 2000* procedures for converting potential capacity to movement capacity are used.) Where shared lanes exist for turning movements, an extra calculation is required to derive the potential (movement) capacity of the shared lane. This step combines the potential capacities for two or three turning movements (depending on the lane configuration) into a single potential capacity. The final capacity of the stop sign-controlled approach is then the sum of all the potential capacities calculated for the turning movements.

Step 1: Calculate Potential Capacity of Each Turning Movement

The procedure starts with *HCM* Equation 17-3. It first calculates the potential capacity for each of the movements on the stop sign-controlled approach:

$$C_{p,x} = CV_{c,x} \frac{e^{-V_{c,x} t_{c,x}/3600}}{1 - e^{-V_{c,x} t_{f,x}/3600}} \tag{30}$$

Where:

$C_{p,x}$	=	potential capacity of movement x (vph)
$CV_{c,x}$	=	conflicting flow rate for each movement x (vph); Table 12
$t_{c,x}$	=	critical gap (seconds) for each movement x
	=	$t_{c,base} + (P_{HV} * t_{c,HV})$
$t_{c,base}$	=	default values from Table 11
$t_{c,HV}$	=	1.0 for one or two-through lane roads (Data Item 34 <= 2)
	=	2.0 otherwise
P_{HV}	=	percent of heavy vehicles in traffic stream, peak period, expressed as a decimal
$t_{f,x}$	=	follow-up time (seconds) for each movement x
	=	$t_{f,base} + (P_{HV} * t_{f,HV})$
$t_{f,HV}$	=	0.9 for one or two-through lane roads (Data Item 34 <= 2)
	=	1.0 otherwise

Table 11. Default Values for Calculating Potential Capacities ($C_{p,x}$) of Stop Sign-Controlled Highways

Vehicle Movement (x)	Base Critical Gap, $t_{c,base}$	Follow-up Time, $t_{f,base}$
Right Turns	6.2	3.3
Through	6.5	4.0
Left Turns	7.1	3.5

Table 12. Default Values for Conflicting Flow Rates

Functional Class	Conflicting Flow Rate, $CV_{c,x}$
Rural Principal Arterials	100
Rural Minor Arterials	150
Other Rural	200
Urban Principal Arterials	250
Urban Minor Arterials	500
Other Urban	750

Clearly, the major assumption in this Step is that of the conflicting volumes. Basically, it is assumed that the intersection is composed of a higher class facility in one direction and a lower class facility in the other. Many stop sign-controlled intersections, particularly those with all-way control, are comprised of similar class facilities intersecting. However, without detailed knowledge of such occurrences, the assumption is a reasonable default.

Step 2: Determine Approach Capacity

Several adjustments to potential capacity are defined in the *HCM 2000* in order to derive "movement capacity". Most of the adjustments are based on knowledge of turning movements on and the geometry of all approaches of the intersection. Since none of these data are available in HPMS, major assumptions would be required. ***As an alternative, the movement capacity is set equal to potential capacity for most cases, except for shared lanes.*** The adjustment for shared-lane capacity is essential for calculating intersection approach capacity. *HCM* Equation 17-15 is used in these cases:

$$C_{p,SH} = \frac{\sum_x V_x}{\sum_x \left(\frac{V_x}{C_{p,x}} \right)} \qquad (31)$$

Where:

$C_{p,SH}$	=	potential capacity of the shared lane (vph)
V_x	=	flow rate of the *x* movement in the shared lane (vph)
$C_{p,x}$	=	potential capacity of the *x* movement in the shared lane (vph) from Equation 1.

Volumes for the turning movements on the intersection approach in question must be made in order to apply Equation 30. It is assumed that 10 percent of the approach volume is composed of left-turning vehicles and 10 percent composed of right turning vehicles (recommended defaults from Chapter 10 of *HCM 2000*). Total approach volume is calculated as:

Approach Volume = AADT * (K * 0.01) * (D * 0.01) (32)

Where:

AADT	=	Data Item 33
K	=	Data Item 85
D	=	Data Item 86
	=	MIN(70, Data Item 86)

Values for V_x are then computed for left turns, through movements and right turns by applying the assumed turning percentages to the approach volume: 10%, 80%, and 10%, respectively.

The number of lanes handling turning movements on the approach are then determined. This is based on Data Items 88 and 89 (Left and Right Turning Lanes) for urban sections and for rural sections where these data are coded. Table 3 shows how to handle each of the possible cases. The approach capacity is based on Equation 30 for nonshared lanes and Equation 31 for shared lanes. In some cases both terms are used. Note that C_A is adjusted to account for the number of lanes handling each movement. Where HPMS indicates "multiple" turning lanes, it is assumed that two such lanes exist. ***For rural sections – or for any sections where Data Items 88 and 89 are coded as zero – it is assumed that no exclusive left turn or right turn lanes exist.***

Table 13. Determining Stop Sign-Controlled Intersection Approach Capacity (C_A)

Left Turning Bay/Lanes Coding (Data Item 88)	Right Turning Bay/Lanes Coding (Data Item 89)	Approach Capacity Calculation, C_A (vph)
0, 4	0, 4	All movements made from a shared lane; $C_A = N_T C_{p,SH}$
	1, 2, 3	Shared LT + T lane; exclusive RT lane; $C_A = N_T C_{p,SH(LT+T)} + N_{RT} C_{p,RT}$
	5	Do not consider right turn volumes; $C_A = N_T C_{p,SH(LT+T)}$
1, 2, 3	0, 4	Shared RT + T lane; exclusive LT lane $C_A = N_T C_{p,SH(RT+T)} + N_{LT} C_{p,LT}$
	1, 2, 3	Exclusive lanes for all movements; $C_A = N_{LT} C_{p,LT} + N_T C_{p,T} + N_{RT} C_{p,RT}$
	5	Do not consider right turn volumes; $C_A = N_{LT} C_{p,LT} + N_T C_{p,T}$
5	0, 4	Do not consider left turn volumes $C_A = N_T C_{p,SH(RT+T)}$
	1, 2, 3	Do not consider left turn volumes $C_A = N_T C_{p,T} + N_{RT} C_{p,RT}$
	5	Consider only through volumes $C_A = N_T C_{p,T}$

Where:

N_T = Number of Peak Through Lanes
= 1 for rural highways with 2 through lanes
= 2 for rural highways with 3 through lanes
= Data Item 87 otherwise

N_{LT} = Number of Left Turn Lanes
= 2 if Data Item 88 = 1
= 1 if Data Item 88 = (2,3)
= 0 otherwise

N_{RT} = Number of Right Turn Lanes
= 2 if Data Item 89 = 1
= 1 if Data Item 89 = (2,3)
= 0 otherwise

$C_{p,SH}$ = potential capacity of the shared lane (vph) from Equation 31 (the terms in parentheses indicate which movements are being handled by the shared lane, e.g., “LT+T” means that left turns and through movements share the lanes

$C_{p,T}$ = potential capacity (assumed to be the movement capacity from Equation

30) for the through movement

$C_{p,RT}$ = potential capacity (assumed to be the movement capacity from Equation 30) for the right turn movement

$C_{p,LT}$ = potential capacity (assumed to be the movement capacity from Equation 30) for the left turn movement

Step 3: Set Peak Capacity to Approach Capacity

For HPMS, the Peak Capacity of the section is then based on the approach capacity of the stop sign-controlled intersection analyzed above. For urban sections, since the HPMS definition of urban capacity is one-way, the Peak Capacity is set equal to the approach capacity. For rural sections, it is based on the total number of through lanes (Data Item 34). This is done to account for the definition of capacity for 2- and 3-lane sections in HPMS, which is two-way capacity.

Rural 4+ through lanes

Peak Capacity = Approach Capacity

Rural 3-through lanes

Peak Capacity = Approach Capacity * 1.67 (assumes that the direction with two lanes is the inventory direction)

Rural 2-through lanes

Peak Capacity = Approach Capacity * 2

URBAN ONE/TWO/THREE LANE HIGHWAY CAPACITY

APPLICATION

These are used on highway sections in urban areas that do not meet the traffic control device density requirement for either signals or stop signs. They can either have one-way or two-way traffic flow, as follows:

- One-Way, One-Lane Highways: Data Item 34 = 1 and Data Item 27 = 1;
- Two-Way, 2/3-Lane Highways: Data Item 34 = (2 or 3) and Data Item 27 = 2; and
- Two-Way, One-Lane Highways: Data Item 34 = 2 and Data Item 27 = 1. This is an unusual occurrence but some states code unstriped highways in this manner. For HPMS, it is assumed that these are in fact two-lane highways. In these cases, lane width is determined as the larger of: (Data Item 54 divided by 2) or seven feet.

Many urban sections in HPMS with 1-3 lanes do not have traffic control devices present on the actual section. However, it is possible that these sections are influenced by traffic control devices upstream and downstream of the section. One approach to capacity estimation for these sections is to assume that the capacity is controlled by “off-section” traffic control devices, probably signals. This approach would use the simplified procedure for calculating signalized intersection capacity since the data required for the detailed procedure are lacking. The other approach is to assume that capacity is strictly a function of the section’s characteristics, not off-section traffic control devices. Three reasons exist for using the latter assumption. First, it is consistent with the HPMS philosophy of using the coded data to the maximum extent possible. Second, states can provide capacity estimates directly if off-section traffic control devices exert a major influence on the section's capacity. Third, even if off-section traffic control devices exist, the spacing of these may be large enough that they don't affect the section's capacity. For these reasons, it assumed that these sections are not under the influence of traffic control devices.

PROCEDURE

The recommended procedure is based on the adjusted saturation flow rate step from the Signalized Intersection procedure:

$$Capacity = s_o N f_w f_{HV} f_p f_a PHF \tag{33}$$

where:

s_o	=	base saturation flow rate per lane (pcphpl);
N	=	number of peak lanes (Data Item 87);
f_w	=	adjustment factor for lane width;
f_{HV}	=	adjustment factor for heavy vehicles in traffic stream;
f_p	=	adjustment factor for existence of parking activity;
f_a	=	adjustment factor for area type;
PFH	=	Peak Hour Factor.

Base Saturation Flow Rate, S_O

The base saturation flow rate is set at 1,900 pcphpl.

Adjustment Factor for Lane Width, f_W

The lane width adjustment factor is based directly on the *HCM 2000* procedure:

$$f_W = 1 + \frac{(W - 12)}{30} \tag{34}$$

where:

W	=	Lane Width (Data Item 54); minimum of 8, maximum of 16

Adjustment for Heavy Vehicles, f_{HV}

The heavy vehicle adjustment factor is based directly on the *HCM 2000* procedure, assuming 2 passenger car equivalents for heavy vehicles:

$$f_{HV} = \frac{100}{100 + HV\,(E_T - 1)} \tag{35}$$

where:

HV	=	percent heavy vehicles
E_T	=	2.0 passenger car equivalents

The percent heavy vehicles factor is the sum of peak combination and single unit trucks (Data Items 81 and 83).

Adjustment for Parking, f_p

The calculation of the parking adjustment factor is:

$$f_p = \frac{N - 0.1 - \frac{18 N_m}{3{,}600}}{N} \tag{36}$$

where:

f_p	=	parking adjustment factor
N	=	number of lanes in lane group
N_m	=	number of parking maneuvers per hour
	=	6 for two-way streets for parking on one side
	=	12 for two-way streets with parking on both sides or one-way streets with parking on one side
	=	24 for one-way streets with parking on both sides (based on *HCM* Exhibit 10 - 20)

When parking is not allowed or unavailable (Data Item 61 = 3), f_p is set to 1.0. It is also set to 1.0 if Data Item 61 = 0.

Adjustment for Area Type

Area type is no longer coded in HPMS. An analysis of 1998 HPMS showed that 9 percent of urban signalized intersections were located in CBDs. The *HCM 2000* indicates that f_a should be 0.9 in CBDs, 1.0 elsewhere. Weighting these values with the findings from the 1998 HPMS data provides a value of 0.991 for f_a for urban conditions.

Peak Hour Factor

As discussed on *HCM* page 10-8, a default value of 0.92 is used for the PHF for urban sections.

HPMS DATA ITEMS USED IN CAPACITY CALCULATIONS

Item Number	Description	Item Number	Description
17	Functional System	80	Speed Limit
27	Type of Facility	81	Percent Peak Single Unit Trucks
30	Section Length	82	Percent Average Daily Single Unit Trucks
33	AADT	83	Percent Peak Combination Trucks
34	Number of Through Lanes	84	Percent Average Daily Combination Trucks
54	Lane Width	85	K Factor
55	Access Control	86	Directional Factor
56	Median Type	87	Number of Peak Lanes
57	Median Width	88	Left Turning Lanes
59	Right Shoulder Width	89	Right Turning Lanes
60	Left Shoulder Width	91	Typical Peak Percent Green Time
61	Peak Parking	92	Number At-Grade Intersections - Signals
70	Type of Terrain	93	Number At-Grade Intersections - Stop Signs
78	Percent Passing Sight Distance - **Rural**	94	Number At-Grade Intersections - Other /No Control

VOLUME/SERVICE FLOW RATIO (V/SF)

The volume-to-service flow (capacity) ratio is determined for each paved rural sample section and all urban sample sections. It is used as a measurement for congestion. The equations to determine the volume-to-service flow ratio are by type of facility. V/SF is not calculated for a sample section that is entirely on a structure (HPMS, Item 27 = 3,4).

Rural two- or three-lane facility:

V/SF = (AADT (HPMS, Item 33) * K-factor (HPMS, Item 85)) / Peak Capacity (HPMS, Item 95)

Rural Multilane and All Urban facilities:

V/SF = (AADT (HPMS, Item 33) * K-Factor (HPMS, Item 85) * Directional Factor (HPMS, Item 86)) / Peak Capacity (HPMS, Item 95)

HPMS DATA ITEMS USED IN V/SF RATIO

Item Number	Description
33	AADT
85	K-Factor
86	Directional Factor
95	Peak Capacity

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